POWER

Volume 55 New York, March 14, 1922 *Number* 11

Order

YOU may as well not have a thing as to have it and not know it. Oftentimes a tool, a fitting, a fixture is wanted and wanted quickly. You send and buy one or at considerable trouble fix up something that will do. And then, a week afterward, when you are rummaging around for something else, you find the very thing you wanted—and you had it all the time.

A habit of order is so important that it not infrequently determines failure or success.

A man succeeds because he does things; and the easier and simpler the doing of them can be made the more of them he will do.

The busiest men are often those who get the least done. Their desks are piled so high with things that need attention that they lose more time in vibrating from one to another and fuming about their congested condition than an orderly man would need to clear the pile away.

The orderly man always has something to do next. If another thing comes up for immediate attention, he does it, but does not let it clutter up his program. And he does things deftly and quickly because he has the means, the information, the references equally well ordered.

An engineer will get along with makeshifts—use things when there are others upon the market more applicable to the purpose, simply because he does not know or think of them. A study of the dealers' catalogs, an indexed file of materials, devices, tools and apparatus that may be useful in his work will make his job easier, his plant better and gain him the credit of being up-to-date.

Some plants are conspicuously clean, orderly and well kept; others are in an eternal clutter. It is a safe bet that the men in charge of the former do more and do it better than the ones in charge of the latter. They will get a job done while the others are hunting up tools and materials. And they will do the little things that keep the plant in order while they are still little things, because it is the work of only a few minutes when everything is readily at hand.

Habits of order in the little things lead to order in the greater—order in reading, orderly thinking and living; and the answer to the question why many a man has been a conspicuous success may be that he has lived a useful and well-ordered life.

F. R. Low

Features That Increase Reliability in Hydro-Electric Plants

In Some Plants Combination Waterwheels and Motor-Driven Exciters Are Favored; in Others a Duplicate System Is Justified To Insure Reliability — Motor-Driven Governor Oil-Pressure Systems Are Preferred

By R. C. DENNY
Operating Engineer, San Joaquin Light and Power Corporation

THE San Joaquin Light and Power Corporation operates ten hydro-electric generating stations ranging in size from 500 to 42,600 kw. Experience in the operation of these stations has taught that the proper and consistent operation of the station auxiliaries is without doubt the most important factor contributing to the reliable operation of the station as a whole.

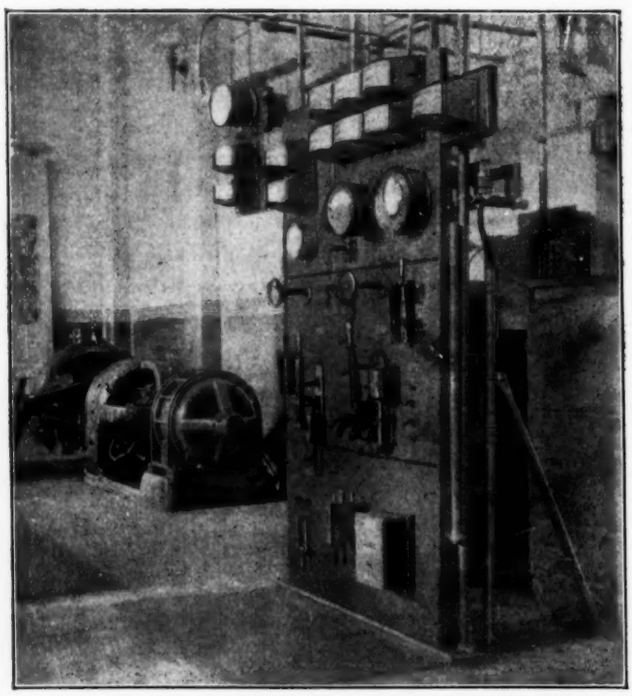


FIG. 1. COMBINATION TURBINE- AND MOTOR-DRIVEN EXCITER SET INSTALLED IN A 3,000-KVA. SINGLE-UNIT STATION

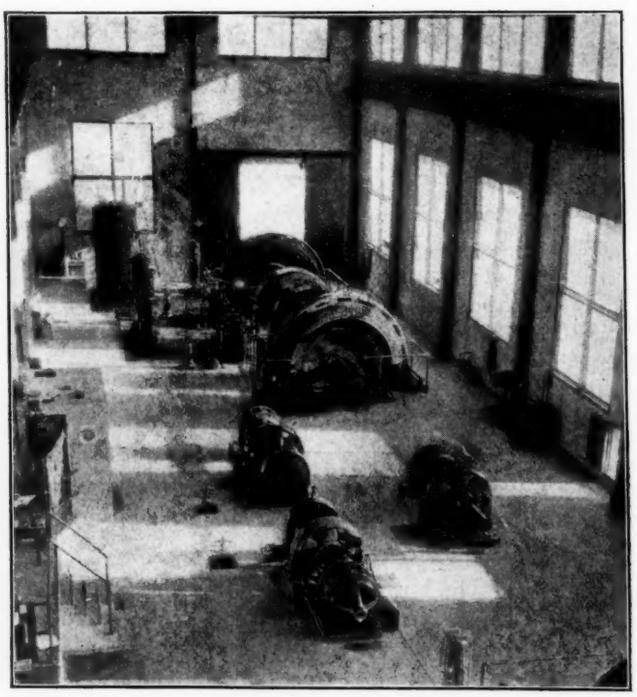


FIG. 2. INTERIOR OF 16,000-KVA. PLANT IN WHICH COMBINATION TURBINE- AND MOTOR-DRIVEN EXCITERS SETS ARE USED

Of prime importance among the auxiliaries is the exciter. This unit, the pulse of the station, must absolutely function properly at all times to guarantee the reliability of the station's operation. Exciter sets should be provided in duplicate in stations that are of sufficient importance to a system to justify the additional investment; while in smaller stations a single exciter with dual drive should suffice. There are several reliable combinations in exciter sets, and a review of the practices of the San Joaquin system in this regard may prove interesting

Modern and medieval methods of excitation employed in the larger stations are illustrated in Figs. 1, 2, 3 and 4. Fig. 1 shows the combination motor-and-turbine driven exciter unit of a 3,000-kva. single-unit station. This plant, although not large, is an important station because for the greater part of the year it must pass stored water to other and more important stations farther downstream. For a period of the year this plant is shut down, which permits general inspection and overhauling of the exciter set and putting it in shape for the subsequent season's run. Ordinarily, the exciter set in this plant operates on the motor drive with enough water turned on the turbine to balance the thrust and keep the bearings cool. There is no governor on the turbine, but that is of little consequence, as there is no voltage regulator to vary its load, so that the operation is entirely satisfactory when running on the turbine alone.

An instance in mind demonstrates the reliability of the foregoing combination for exciter drive, in which case the leads between the compensator and the motor, which operates at 2,300 volts, broke down to ground, interrupting power to the motor. Additional water was turned on the turbine at once and operation resumed while a permanent repair was being made to the motor circuit, which required two days. In such a station there is always the possibility of requiring the

generator to operate as a motor for power-factor correction, which may be done with a minimum use of water during the storage season. Thus it is felt that for such a station the combination of exciter with both turbine and motor drive is the most economical and at the same time a reliable system of excitation.

In Fig. 2 is shown one of the corporation's more important stations, a four-unit plant of 16,000-kva. capacity. The two main exciters in this station can be seen in the center foreground and have a dual drive, the hydraulic end in this case being an impulse wheel. This plant is of sufficient size and importance to the system to justify the duplication. A third unit will be noticed in the right foreground; this is a motor-driven direct-current generator used for control purposes and station lighting, but in an emergency it may be used for excitation also. No governors are provided on the waterwheel of the dual drives, as their operation is only for emergencies; however, there is always enough water turned on the wheels to meet any emergency. A Tirrill voltage regulator is in use at this station, which effectively takes care of the excitation during system disturbances when the frequency of the generators may be somewhat decreased.

In this plant it is possible to separate the generators from the low-tension bus and run entirely on the high-tension bus, and in several instances it has been necessary to do this while working on the low-tension. In such cases the Tirrill regulator is taken out of service and the exciters run on the waterwheels. In the ten years of this plant's operation this system of excitation has proved to be very reliable, and there have been no

FIG. 3. INTERIOR OF 42,600-KVA. PLANT IN WHICH DUPLICATE TURBINE-DRIVEN EXCITERS ARE USED

shutdowns due to any inherent operating difficulties whatever.

On the right in Fig. 3 is shown the exciter arrangement at the Kerckhoff hydro-generating station of 42,600-kva. capacity. This station was of such importance to the system as to justify absolutely the most reliable system of excitation, providing as well, for a duplicate unit. Two vertical reaction turbine sets were installed as shown, without governors, each unit having ample capacity for the station. After the plant was put into service, it was soon evident that the operation of these units in connection with the Tirrill regulator was entirely impractical if not impossible, therefore no time was lost in ordering governors and installing them. The small units mounted above the main exciters are 125-volt control units, excitation in this station being at 250 volts. This layout in our opinion is without doubt the most reliable combination possible, and in view of the importance of the plant to the system the expense was justified. Further, a two-exciter station may be made a very flexible one, which is the case at Kerckhoff; it being necessary to separate one or two units in the station and run them on an interconnected system. In such cases it is of considerable advantage to have independent sources of excitation, in order that the voltage requirements of one system may be maintained without affecting the other.

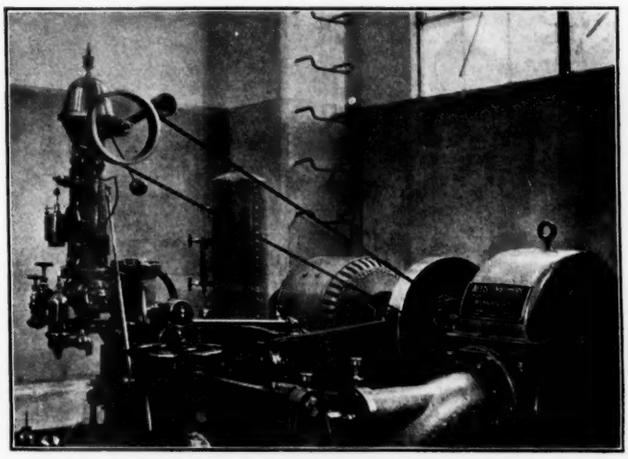


FIG. 4. WATERWHEEL DRIVEN CONTROL SET FOR EXCITING FIELDS OF DIRECT-CONNECTED EXCITER ON 10,600-KVA. UNIT

At the new Kern Canyon station is installed a single 10,600-kva. unit. In the general scheme of excitation for this unit several new ideas were incorporated which have proved to be both economical and reliable. The exciter, a direct-connected one, is electrically connected to the generator field below it through a double-pole breaker with discharge resistance. There is no generator-field rheostat, so voltage adjustments are made with the exciter field rheostat, the range of exciter voltage being between 35 and 125. The exciter may be run self-excited, but this is hardly considered reliable during system disturbances when the frequency may be somewhat lowered. Therefore, the exciter field is energized externally from a direct-current generator waterwheel set. This control set is complete with governor, as shown in Fig. 4, and furnishes current for operating all switches, motor-operated valves and emergency lighting. A motor-generator control set is also provided for emergency service.

Such dependable methods of excitation as described in the foregoing, entirely obviate the use of storage batteries in the generating station for emergency excitation or control either. Furthermore, it might be said that operating experience has repeatedly demonstrated the superiority of the waterwheel exciter over steam ex-

citer sets, which practically amounts to the difference in reliability between their respective governor systems.

In this connection might well be discussed governor oil-pressure systems and their bearing on the general plant reliability. Several such systems are in use in the hydro-electric stations of the San Joaquin Light and Power Corp. However, in every case each governor has its own or individual oil-pressure system. In some cases the oil pump and reservoir are self-contained in

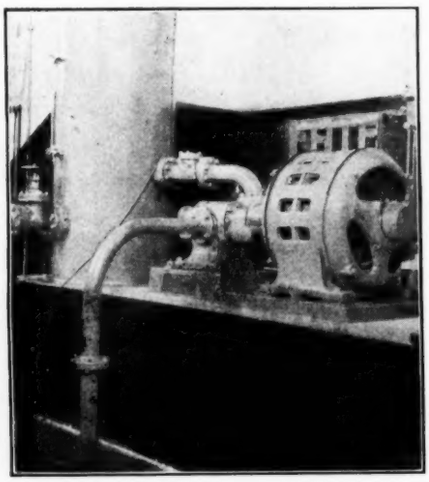


FIG. 5. MOTOR-DRIVEN UNITS FOR GOVERNOR OIL-PRESSURE SYSTEM

the governor and driven by belt from the shaft of the main unit, while in others the pump and tank are entirely separate from the governor but driven by the same method. Either of these systems has the disadvantage that, in starting up with the governor pressure down, the unit has to be put on hand control and run long enough to pump up the pressure, which is rather like putting a man to a boy's task. At any rate such procedure results in a waste of water, though time might not be of any consequence. If the machine be synchronized and put on the bus and left on hand control while pumping up the governor pressure, serious trouble might arise in handling the unit should line trouble develop during the interval. The latter is the method in practice, however, as there is no desire to waste either time or water in getting on the line. In such instances the floorman stands by the hand control until the governor oil pressure is up and then cuts the unit over to governor control.

Another objection to the governor oil pump being belted to the main unit, unless to the end of the shaft, is that the machine has to be shut down to replace a broken belt. The breaking of a governor-pump belt might or might not cause considerable trouble, depending upon how soon the floorman noticed it. The more dependable method would be geared motor drive, which practice is being adopted in the newer stations.

In Fig. 5 is shown one of the three governor oil-pressure units at the Kerckhoff station, which is the same type used at the Kern Canyon station. The pumps run continuously when their respective governors are in service, and while not pumping against pressure, discharge back into the oil reservoir, which is beneath the floor near the pressure tank. The oil piping is so arranged that each pressure system may operate its respective governor separately or pump into a common header from which all the governors may be operated. This permits any pump unit to be shut down for inspection or repairs. The exciter governors are normally operated off the oil pressure system of the units adjacent to them. To further insure the reliability of the governor oil-pressure system, the motors are fed from the generator bus through a bank of transformers entirely separate from the other station auxiliaries, but arranged to be thrown over to the station auxiliary bus in case of necessity.

The governors that are in use in both the Kerckhoff and the Kern Canyon stations have an additionally reliable feature which is inherent in the design. The flyballs that actuate the valves in the governor head through a system of levers and cranks, are attached to the shaft of the main unit. Hence the action is very positive and reliable in that there are no belts involved, to slip or break and cause trouble. Since the reliable operation of such an oil-pressure system depends to the greatest extent upon the reliability of the source of power, which is the generator bus itself, it is felt that the expense of a waterwheel-driven pump would be entirely unjustified.

[This article is part of a paper to be submitted at the Pacific Coast Section Convention of the N.E.L.A.—EDITOR.]

Cement-Gunning a Boiler Furnace

There is nothing particularly new about the cement gun, or in the use of refractory material for lining boiler furnaces, but the use of the cement gun for applying the refractories is out of the ordinary.

A representative of *Power* witnessed such a demonstration a short time ago, at one of the boiler plants of the Tidewater Oil Co., at Bayonne, N. J. The boiler furnace being lined was under a 5,000-sq.ft. boiler, using fuel oil, in which a furnace temperature of between 2,800 and 3,000 deg. F. is maintained, depending on the load being carried by the boiler.

The work was done by a cement gun supplied by the Cement Gun Co., Inc., in which Bondite cement was used. The cement was placed in the gun in a dry state. Then air pressure was applied to the reservoir of the gun, which pressure forced the dry cement through a rubber hose to a mixing nozzle, to which a water hose made connection. The water was regulated by the nozzleman in quantity just sufficient to form the cement into a soft plastic stream as it was blown from the nozzle. The nozzle was held about three feet from the surface to be covered.

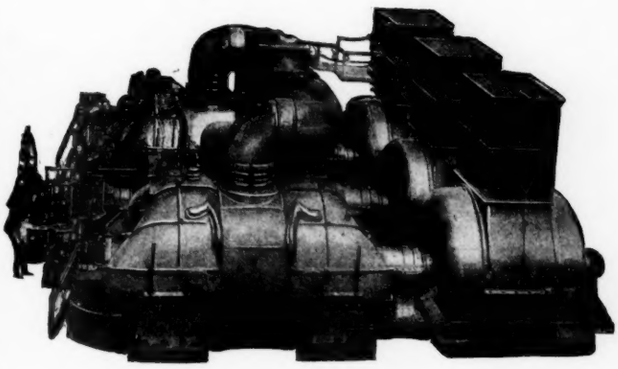
If not enough water is supplied, the placed material will appear dry; if too much water is used, the material will run off or slip from the wall. When the proper amount of water is used with the dry cement, the surface of the mixture when applied to the wall shows a glossy finish.

The gun, when fully loaded, holds 200 lb. of cement, but the design is such that new cement can be added as wanted, so that when once started the work of covering the furnace wall can be carried on to completion without stopping. The cement was put on with an average thickness of $\frac{1}{2}$ in. and the 325 sq.ft. of furnace-wall area was covered in 55 minutes.

The finished job shows a smooth surface, all crevices between the firebricks being filled with the cement and the whole making an unbroken surface of refractory lining.

Efficiency Tests of a 60,000-Kw. Turbine*

Results of tests on the 60,000-kw. turbine installed in the Seventy-fourth Street Power Station of the Interborough Rapid Transit Company. The lowest water rate obtained while operating the complete units under normal conditions was 11.00 lb. per kw.-hr., while the highest Rankine and thermal efficiencies obtained were 76.0 per cent and 25.1 per cent respectively. With the high-pressure and one low-pressure turbine in service the lowest water rate was 11.25 lb.



By HERBERT B. REYNOLDS and WALTER F. HOVEY†

THE engine room, Seventy-fourth Street station, Interborough Rapid Transit Co., New York City, originally contained eight 7,500-kw. double angle-compound engine units of the Manhattan type and similar to the engines that were later installed in the Fifty-ninth Street power station. During 1905 a 5,500-kw. turbine was installed, the capacity of which was subsequently increased to 8,000 kw. by rewinding the generator. In order to provide space for the three 30,000-kw. Westinghouse turbines, the installation of which was completed in 1915, it was necessary to remove four of the Manhattan engine units. A fifth engine unit was removed in 1916 in order to provide space for the 60,000-kw. unit, the installation of which was completed in 1918. A general view of the turbine is shown in the headpiece and it is of the cross-compound, triple-cylinder type, consisting of one high-pressure element and two

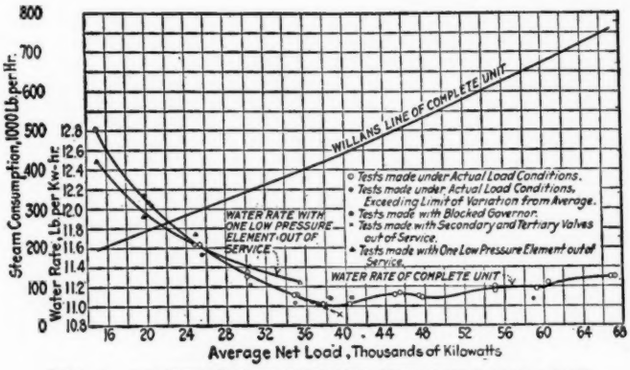

Steam Consumption, 1000 Lb. per Hr.
Water Rate, Lb. per Kw-hr.
WILLANS LINE OF COMPLETE UNIT
WATER RATE WITH ONE LOW PRESSURE ELEMENT OUT OF SERVICE
WATER RATE OF COMPLETE UNIT
○ Tests made under Actual Load Conditions.
• Tests made under Actual Load Conditions, Exceeding Limit of Variation from Average.
• Tests made with Blocked Governor.
• Tests made with Secondary and Tertiary Valves out of Service.
• Tests made with One Low Pressure Element out of Service.
Average Net Load, Thousands of Kilowatts

FIG. 1. WATER-RATE CURVES AND WILLANS LINE FOR 60,000-KW. TURBINE

low-pressure elements, each element driving a separate generator.

The normal steam pressure at the throttle is 220 lb. absolute, with a superheat of 150 deg. F. exhausting into a vacuum of 29 in. referred to a 30-in. barometer at 58.1 deg. F. The speed of all three elements is 1,500 r.p.m.

Steam is supplied to the unit through two steam lines, each one of which is provided with a throttle. After passing through the throttle, the steam enters a common chamber. The use of two small lines gives greater flexibility and increases the reliability somewhat.

The high-pressure element is of the single-flow straight reaction type having a total of twenty-five stages. In addition to the primary steam inlet, which takes care of all loads up to 40,000 kw., secondary and tertiary inlet connections are provided. The secondary inlet bypasses the first six stages and is opened automatically by the governor at a load of approximately 40,000-kw. This secondary inlet takes care of all loads up to 50,000 kw., after which the tertiary inlet, which bypasses the first ten stages, opens and increases the capacity to 60,000 kw. The generators are able to carry a maximum load of 70,000 kw. for two hours. In order to carry this load, a hand-operated quaternary valve has been provided which bypasses four additional stages. After passing through the high-pressure element the steam is exhausted through a connection shown on top of the casing, and is led to each of the low-pressure turbines, which are of the semi-double flow type. The steam enters through the top of the casing and passes through a single-flow element consisting of ten stages. After passing through this intermediate section, the steam divides and passes through two low-pressure sections, each containing six stages, after which it is discharged to the condenser.

The unit is provided with a number of automatic features which makes it possible for any one of the three elements to go out of service and allow the remaining elements to remain on the line to take care of the load. It has not been possible to make full use of these automatic features up to the present time, due to the absence of a relief valve on the exhaust of the high-pressure turbine.

Each low-pressure element is provided with a live-steam connection and a governor adjusted for a wide regulation, approximately 12 per cent, while the governor on the high-pressure unit is adjusted to a close regulation. The governor on each low-pressure element will in the outer part of its travel close a butterfly valve in the line between the high-pressure and low-pressure turbines. When these governors reach the inner positions they begin to admit and regulate high-pressure steam to the low-pressure turbines. There is a zone

*Abstract of paper presented before the Metropolitan Section of the A. S. M. E., and the New York Section A. I. E. E., New York, Feb. 24, 1922. To be read by title at the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of the American Society of Mechanical Engineers.

†Engineers, motive-power department, Interborough Rapid Transit Company.

between these two positions in which the motion of the governor has no effect. This zone is sufficiently wide to cover the total speed variation of the machine when operating normally so that the low-pressure governors have no function to perform during normal operation.

Each element is provided with a stop governor which closes the automatic throttle admitting live steam to the low-pressure turbine and the butterfly valve admitting low-pressure steam to the low-pressure turbines only, while the automatic stop governor on the high-pressure will close the main automatic throttle valve only. There is a switch arranged in connection with each of the three automatic throttle valves so that when the automatic throttle valve operates, this switch opens the oil switch of whichever turbine element is involved.

The exhaust of the high-pressure turbine is to be provided with a relief valve which, in the event of one of the low-pressure turbines being thrown out of service by the closing of the butterfly valve, will permit the surplus exhaust steam to escape to the atmosphere. This valve will be set to that pressure corresponding to the maximum load on one of the low-pressure turbines which the generator can sustain without injury for a brief period

The generators are three-phase star-connected, generating 25-cycle current at 11,000 volts. Excitation current is furnished at 250 volts. The generators are cooled by a circulation of air maintained by a fan which forms an integral part of the generator. The air is drawn from the turbine-room basement and discharged from the top of the generator into the turbine-room through a short stack which may be seen in the headpiece. Each generator is connected through an oil switch to a short bus, which in turn is connected to the

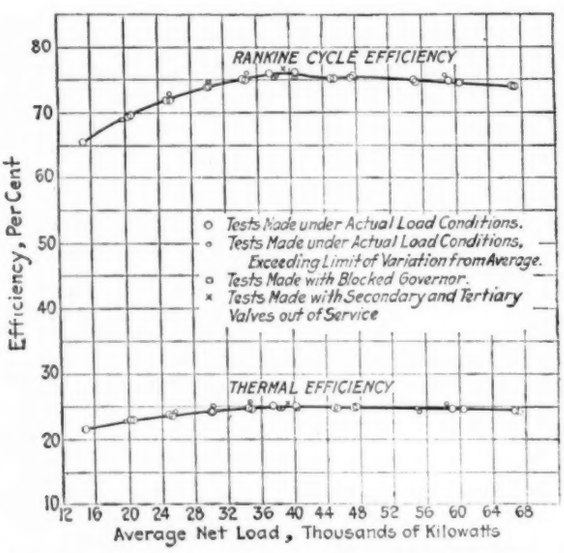

RANKINE CYCLE EFFICIENCY
THERMAL EFFICIENCY
Efficiency, Per Cent
Tests Made under Actual Load Conditions.
Tests Made under Actual Load Conditions, Exceeding Limit of Variation from Average.
Tests Made with Blocked Governor.
Tests Made with Secondary and Tertiary Valves out of Service
Average Net Load, Thousands of Kilowatts

FIG. 2. RANKINE-CYCLE AND THERMAL-EFFICIENCY CURVES FOR 60,000-KW. TURBINE

station bus through another oil switch. This arrangement permits all three generators to be brought up to speed and synchronized simultaneously.

The condensing equipment for each low-pressure turbine consists of a two-shell, two-pass Westinghouse condenser, two centrifugal circulating pumps each driven through reduction gears by turbines, and two centrifugal condensate pumps each driven by a turbine. The entire unit is served by three LeBlanc air pumps.

Each condenser shell contains 25,000 sq.ft. of tube surface made up of 5,300 tubes, 18 ft. long, 1 in. outside diameter and of No. 18 B.w.g. thickness. A portion of the tube surface next to the turbine exhaust amounting to 1,200 sq.ft. is used as a preheater through which the condensate is circulated.

Details of Turbine Test

Although the turbine was first placed in complete operation on Oct. 11, 1918, the tests were not run until July, 1921. The equipment used for conducting the turbine tests consisted of two large water tanks for

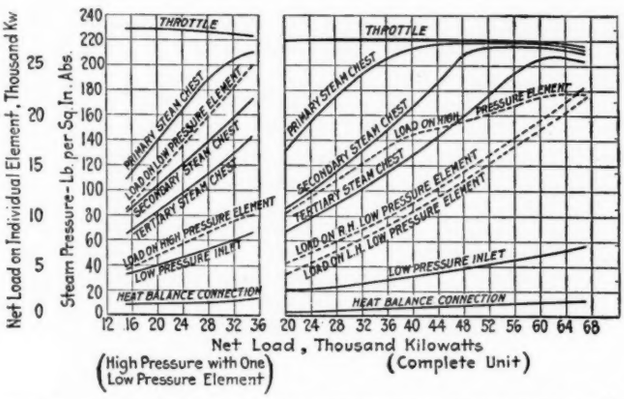

Net Load on Individual Element, Thousand Kw
Steam Pressure - Lb. per Sq. In. Abs.
THROTTLE
PRIMARY STEAM CHEST
LOAD ON LOW PRESSURE ELEMENT
SECONDARY STEAM CHEST
TERTIARY STEAM CHEST
LOAD ON HIGH PRESSURE ELEMENT
LOW PRESSURE INLET
HEAT BALANCE CONNECTION
LOAD ON HIGH PRESSURE ELEMENT
LOAD ON R.H. LOW PRESSURE ELEMENT
LOAD ON L.H. LOW PRESSURE ELEMENT
Net Load, Thousand Kilowatts
(High Pressure with One Low Pressure Element)
(Complete Unit)

FIG. 3. VARIATION OF STEAM PRESSURE WITH THE LOAD AT VARIOUS POINTS THROUGHOUT THE TURBINE

measuring the steam consumption, three single-phase rotating standard watthour meters for measuring the output, and all the necessary thermometers, gages and mercury columns for determining temperatures, pressures and vacua as recorded in this report.

The water-measuring tanks had a capacity of 300,000 lb. each. These tanks were very carefully calibrated before the tests by filling them with water weighed on platform scales. The condensate was measured throughout the tests by alternating from one tank to the other, one tank being filled while the other was being emptied. Corrections were made for variation of the temperature of the water. Corrections were also made for condenser leakage, which amounted to only about 0.05 per cent. This leakage was determined by titration. The rotating standard watt-hour meters which were used for measuring the output were calibrated several times throughout the tests by the Electrical Testing Laboratories, New York City. It is believed that both the input and output were measured within an accuracy of 0.5 per cent. All thermometers and gages were also calibrated in the usual manner. The specific gravity of the mercury used in the vacuum columns was determined and corrections made accordingly. The readings obtained from the mercury columns were further corrected for meniscus, temperature and barometer reading. The barometer reading was obtained from the local United States Weather Bureau.

Almost all of the tests were of three hours' duration. With the exception of a few special tests, the turbine was operated under normal conditions in so far as type of load was concerned. The load was controlled from the switchboard through the remote governor-control system provided for that purpose. This method of controlling the load subjected the turbine to the full swings of the railroad load.

Two series of tests were run, one with the complete

unit in service and the other with the high-pressure and one low-pressure turbine in service.

The table gives the numerical results of the turbine tests, while the performance is shown graphically in Figs. 1, 2 and 3. Fig. 1 gives the total steam consumption and water rate of the unit, while Fig. 2 gives the thermal and Rankine-cycle efficiencies. From these curves it will be seen that the lowest water rate obtained while operating the complete unit under normal conditions was 11.00 lb. per kw.-hr., while the highest Rankine

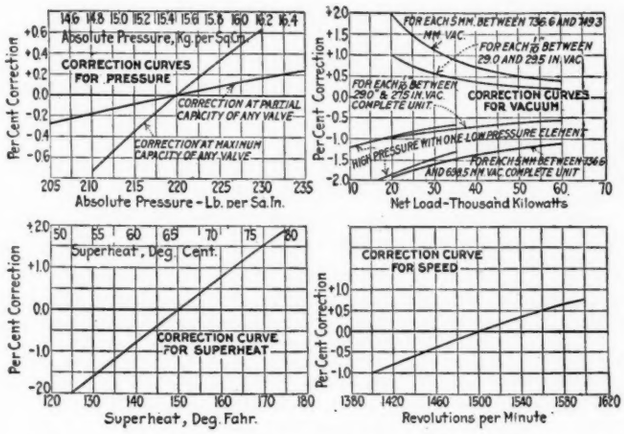

Absolute Pressure, Kg. per Sq.Cm.
CORRECTION CURVES FOR PRESSURE
CORRECTION AT PARTIAL CAPACITY OF ANY VALVE
CORRECTION AT MAXIMUM CAPACITY OF ANY VALVE
Per Cent Correction
Absolute Pressure - Lb. per Sq.In.
FOR EACH 5 MM. BETWEEN 736.6 AND 749.3 MM. VAC.
FOR EACH IN. BETWEEN 29.0 AND 29.5 IN. VAC.
FOR EACH IN. BETWEEN 28.0 & 27.5 IN. VAC. COMPLETE UNIT
CORRECTION CURVES FOR VACUUM
HIGH PRESSURE WITH ONE LOW PRESSURE ELEMENT
FOR EACH 5 MM. BETWEEN 736.6 AND 698.5 MM. VAC. COMPLETE UNIT
Net Load - Thousand Kilowatts
Superheat, Deg. Cent.
CORRECTION CURVE FOR SUPERHEAT
Superheat, Deg. Fahr.
CORRECTION CURVE FOR SPEED
Revolutions per Minute

FIG. 4. CURVES FOR CORRECTING STEAM CONSUMPTION TO THE STANDARD CONDITIONS

and thermal efficiencies obtained were 76.0 per cent, and 25.1 per cent respectively. With the high-pressure and one low-pressure turbine in service the lowest water rate was 11.25 lb. per kilowatt-hour.

It will also be noticed in Fig. 1 that the water rate of the unit when the high-pressure and one low-pressure turbine is in service is better than that for the complete unit at loads below 25,000 kilowatts.

A few tests were run with the governor blocked so that the unit operated under a steady load. These tests are shown in Figs. 1 and 2 by the small squares. It will be seen that there is no improvement in the efficiency under the steady load conditions at the loads selected for these tests. The test shown by the cross in Figs. 1 and 2 was run with the secondary and tertiary valves out of commission, while the load was adjusted so that the primary valve was wide open. As is to be expected, the lowest water rate was obtained while operating in this manner. Test No. 7 was run without any load on the generator, but with the field excited to give normal voltage on open circuit. The actual steam consumption per hour during this test amounted to 32,428 lb. No attempt was made to correct the steam consumption during this test, owing to the load being outside the vacuum correction curves.

Fig. 3 shows the variation of steam pressure with the load at various points throughout the turbine. The curves in Fig. 4 were used for correcting the steam consumption to the standard conditions of 220 lb. absolute steam pressure, 150 deg. F. superheat, 29 in. Hg. vacuum and 1,500 r.p.m. These curves were furnished by the manufacturer; however, the vacuum curves were checked to some extent by actual tests.

Water-Rate Factor

In order to make an absolute and numerical comparison of the flatness of water-rate curves for different turbines, an expression has been used which is termed the "water-rate factor." Expressed mathematically,

$$F = \frac{MW}{C}$$

in which

F = Water-rate factor;
M = Minimum water rate obtained;
W = Mean load between one-half rated load and maximum load, which is the usual operating range;
C = Average total steam consumption per hour covering the range between one-half rated load and maximum load.

Using the curves given in Fig. 1, substitutions may be made as follows:

$$F = \frac{11.00 \times 50{,}000}{558{,}925} = 0.984$$

SUMMARY OF TESTS MADE ON THREE-CYLINDER CROSS-COMPOUND 60,000-KW. TURBINE

Tests No.	Tests Hr.	Average Load Net Kw. Total	Low-Pressure Element, Right	High-Pressure Element	Low-Pressure Element, Left	Output Kw.-Hr. Gross Total	Output Kw.-Hr. Net Total	Excitation,[3] Kw.-Hr.	Steam at Throttle Lb. per Sq.In. Abs.	Steam at Throttle Superheat, Deg. F.	Steam at Throttle Temp., Deg. F.	Exhaust Vac.[1] In., Hg.	Total Water Actual Lb.	Total Water Corrected[2] Lb.	Water Rate, Lb. Per Kw.-Hr.	Rankine Cycle Eff., Per Cent	Thermal Eff.,[2] Per Cent
8	3	15,038	3,955	7,128	3,955	45,579	45,114	465	230.0	145.2	539.0	29.11	569,704	578,085	12.81	65.3	21.5
32	3	20,534	5,195	10,986	4,353	62,082	61,602	480	221.4	128.6	519.1	28.56	784,970	741,357	12.03	69.5	22.9
34	3	25,274	7,026	12,511	5,737	76,319	75,822	497	219.0	127.1	516.6	28.45	940,025	881,487	11.63	71.9	23.7
26	3	30,102	8,128	14,750	7,224	90,814	90,306	508	221.7	141.3	531.9	28.44	1,075,971	1,023,660	11.34	73.6	24.3
28	3	34,798	9,500	16,390	8,908	104,916	104,395	521	221.0	134.0	524.3	28.38	1,229,740	1,161,006	11.12	75.2	24.8
45	3	37,605	10,567	17,449	9,589	113,354	112,816	538	221.6	131.5	522.0	28.15	1,337,720	1,243,581	11.02	75.9	25.0
17	3	40,332	10,567	18,149	11,616	121,532	120,997	535	219.4	138.5	528.2	28.27	1,414,619	1,333,596	11.02	75.9	25.0
37	3	44,910	13,473	18,683	12,754	135,297	134,729	568	222.0	137.3	528.0	28.08	1,603,180	1,496,472	11.11	75.3	24.8
27	3	47,647	14,533	19,535	13,579	143,514	142,940	574	220.4	133.8	523.9	28.03	1,703,985	1,584,600	11.09	75.4	24.9
35	3	55,063	17,675	20,703	16,685	165,792	165,189	603	220.0	149.9	539.8	28.07	1,949,370	1,849,497	11.20	74.6	24.6
33	3	60,456	19,708	22,006	18,742	181,996	181,368	628	218.7	155.7	545.1	28.09	2,128,240	2,036,007	11.23	74.4	24.6
42[4]	2	66,860	22,866	22,265	21,729	134,159	133,719	440	217.0	163.4	552.2	27.00	1,646,720	1,510,474	11.30	74.0	24.4
19[4]	2	67,168	22,971	21,763	22,434	134,785	134,336	449	216.2	158.8	547.3	27.33	1,634,762	1,517,722	11.30	74.0	24.4
10[5]	2	19,902	4,916	10,210	4,776	40,117	39,803	314	228.2	151.0	544.1	28.45	506,383	482,362	12.12	69.0	22.8
13[5]	2	30,307	7,940	14,608	7,759	60,942	60,613	329	229.2	161.2	554.7	28.36	707,655	680,174	11.22	74.5	24.6
14[5]	3	40,547	11,596	17,841	11,110	122,181	121,641	540	224.0	139.0	530.5	28.33	1,416,240	1,348,530	11.09	75.4	24.9
22[6]	3	39,316	11,009	17,810	10,497	118,480	117,948	532	221.5	129.4	519.9	28.34	1,366,777	1,287,672	10.92	76.6	25.3
7[7]	1	No load	.....	.....	.....	.....	.....	154	227.9	155.0	550.0	28.34	32,428	.....	.....	.....	.....
3[8]	2	15,038	10,151	4,887	.....	30,292	30,077	215	224.7	134.0	526.0	28.51	399,500	375,612	12.49	66.9	22.1
5[8]	2	19,842	13,433	6,409	.....	39,907	39,685	222	222.6	136.0	527.0	28.35	507,630	473,934	11.94	70.0	23.1
2[8]	2	24,934	16,955	7,979	.....	50,104	49,868	236	222.0	140.0	531.0	28.31	622,980	585,672	11.74	71.2	23.5
4[8]	2	30,168	20,424	9,744	.....	60,579	60,337	242	218.0	142.0	531.0	28.04	740,880	688,486	11.41	73.3	24.2
6[8]	2	35,391	24,597	10,794	.....	71,044	70,782	262	214.9	142.0	530.0	27.37	886,050	795,368	11.24	74.4	24.5

[1] Referred to 30 in. barometer at 58.1 deg. F. [2] As corrected to 220 lb. per sq.in. abs. pressure, 150 deg. F. superheat and 29 in. vacuum referred to 30-in. barometer at 58.1 deg. F. [3] Including rheostat loss. [4] Tests Nos. 19 and 42 made with hand-operated quaternary valve wide open. [5] Tests Nos. 10, 13 and 14 made with governor adjusted to limit maximum loads to values shown in third column. [6] Test No. 22 made with secondary and tertiary valves out of service. [7] Test No. 7 made without load on generators, with generator field currents adjusted to give normal voltage on open circuit. [8] Tests Nos. 2, 3, 4, 5, and 6 made on high-pressure and right-hand low-pressure elements only, with left-hand low-pressure element out of service.

Methods of Measuring Temperatures in Electrical Machinery

Principle on Which Both the Thermocouple and Temperature Coils Operate—How These Devices Are Applied to Measuring the Temperature of Electrical Generators—Both Direct Reading and Graphic Instruments May Be Used

By S. H. MORTENSEN
Electrical Engineer, Allis-Chalmers Manufacturing Company

IN LARGE modern electrical generators it has become general practice to provide means for measuring the temperature of the windings in the core slots. This is accomplished by locating thermocouples or temperature coils in contact with the coil insulation in the slots. These devices are connected to suitable instruments of either the direct-reading or recording type. These instruments are usually located in the control room so that the operator may know the temperature of the machine at all times.

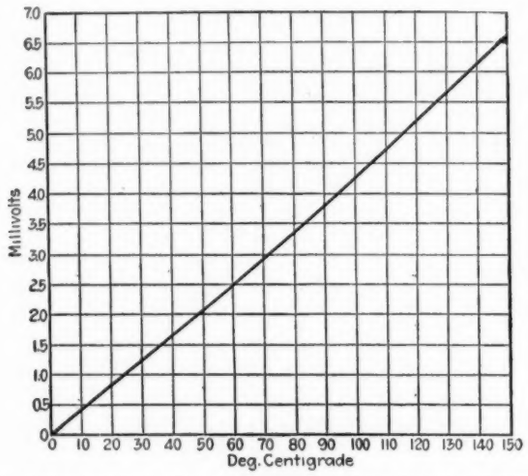


FIG. 1. MILLIVOLTS PER DEGREE DIFFERENCE BETWEEN TEMPERATURES OF HOT AND COLD JUNCTIONS OF THERMOCOUPLE MADE FROM COPPER AND CONSTANTAN WIRE

In principle the thermocouple detector is based on the electromotive force that is set up when the ends of two dissimilar metals are joined. The electromotive force in the two junctions are opposing each other in the circuit, and as their respective values are dependent on the temperatures of the junction points, the resultant electromotive force is a measure of the temperature difference between the two junctions. By placing one junction in the hottest portion of the machine and the other junction outside the machine, a definite measurable electromotive force will develop.

Fig. 1 is a curve giving the electromotive force that develops per degree centigrade difference between the temperature of the cold and hot junctions of a thermocouple made from constantan and copper. With the aid of this curve and a millivoltmeter, suitable for measuring the resulting electromotive force of the couple, it is possible to determine the temperature difference between the two junctions. Furthermore, a voltmeter, with a scale calibration in degrees instead of millivolts, connected to a thermocouple whose cold junction is kept at zero, will indicate the hot-junction temperature.

In practical operation the accuracy of a meter of this kind is handicapped by the difficulties in maintaining the temperature of the cold junction constant and also by its being sensitive to the variation in the ohmic resistance of the thermocouple and connecting leads. These difficulties have been eliminated in the instruments that are constructed on the principle of the potentiometer. In the latter, instead of measuring the electromotive force directly as with a voltmeter, the value is determined by comparing it to a known electromotive force, by means of a potentiometer, which is the electrical equivalent to a balance-arm scale. With the balance-arm scale measurements are made by varying known weights until they equal the unknown weights. In a similar manner, measurements are made with a potentiometer by varying a known electromotive force until it equals the unknown electromotive force.

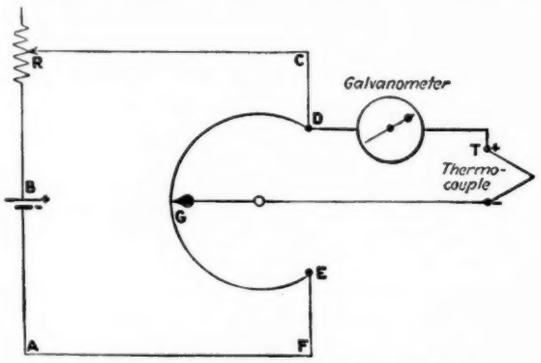


FIG. 2. POTENTIOMETER METHOD OF MEASURING TEMPERATURES

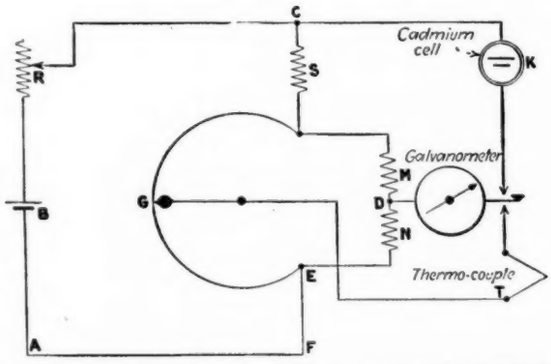


FIG. 3. MODIFICATION OF POTENTIOMETER METHOD TO COMPENSATE FOR TEMPERATURE VARIATIONS

To accomplish this, the potentiometer provides a known variable electromotive force, suitable electrical connections for bringing the electromotive force to a point, where it may be balanced against the unknown force of the thermocouples, and a galvanometer that

indicates when this balance occurs. This arrangement is shown in its simplest form in Fig. 2, where B is a battery that sends a current I through the potentiometer circuit $BCDEFA$. The resistance R is provided for adjusting the current I, and DE is a uniform slide-wire resistance with an adjustable contact G. The current I is constantly flowing through the potentiometer circuit and undergoes a fall in potential, proportional to the circuit resistance. Between D and E, and G and D is thus established an electromotive force, which is proportional to the length of the slide wire. For a fixed value of I the drop of the electromotive force is constant per unit length and the slide-wire scale can be calibrated to read electromotive force similar to a voltmeter.

As shown in Fig. 2, the couples are connected to the potentiometer in such a manner that the direction of their electromotive force opposes the electromotive force across DG, and G is then adjusted until the galvanometer deflection becomes zero, when the electromotive force across GD becomes equal to the electromotive force of the couples, and the value of the latter can be read on the potentiometer scale.

With the aid of a curve such as is shown in Fig. 1, the slide-wire scale can be calibrated in degrees C., corresponding to the respective values of electromotive force, and the temperature of the hot thermocouple junction can be read directly. The foregoing is based on the assumption that the temperature of the cold junction of the couples is constant, which is not the case except where special provisions have been provided for this purpose. However, modern instruments provide

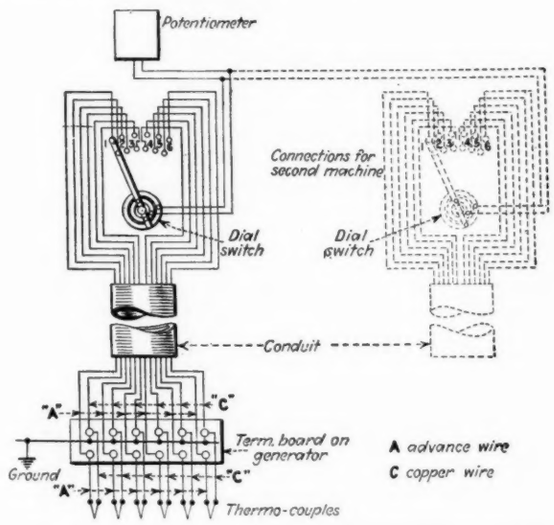


FIG. 4. INSTALLATION OF SIX THERMOCOUPLES

In practice the different machine connections can be isolated from the potentiometer by a switching arrangement, not shown in the figure.

means for compensating the influence of these temperature variations. One method for accomplishing this is shown in Fig. 3, which is a modification of Fig. 2. One end of the cold-end junction of the couples is connected to the junction point of two resistances M and N, connected across the terminals of the slide-wire resistance. Here M is a constant resistance coil and N is a coil made from material with a high temperature coefficient. Their relative values are so chosen that their combined influence upon the balancing position G compensates for the temperature variations of the cold end of the thermocouple.

Furthermore, provisions are made for checking and keeping constant the potentiometer current I by means of a constant-voltage cell K, Fig. 3, which is connected to the potentiometer circuit at C and D. When the current I is checked, the galvanometer is thrown into the circuit in series with K; R is adjusted until I causes a drop in potential across the standard resistance S, equal

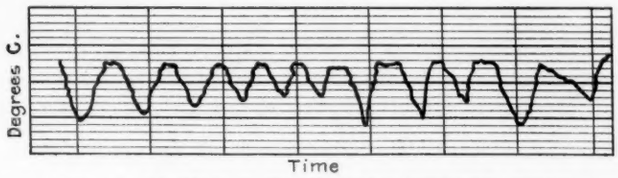


FIG. 5. SAMPLE RECORD FROM TEMPERATURE RECORDING INSTRUMENT

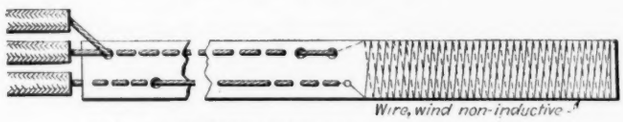


FIG. 6. RESISTANCE UNIT OF DETECTOR

to the electromotive force of K. When this condition is reached, the galvanometer will indicate a balance.

Fig. 4 shows an installation with six thermocouples. With this arrangement the cold junction is formed at the potentiometer, and the leads from the couple to the instrument for that reason must be made from the same material as the part of the couples to which it connects. In installations where the compensated type of instrument is used and where the distance between the thermocouples and the indicating instrument is large, it may be necessary to mount the cold couple of the instrument on the terminal board of the machine. Where this is done, all connections from this board to the instrument can be made with copper wire.

Instead of using indicating instruments with the thermocouples, recording instruments may be used. One instrument of this kind has been worked out upon the principle of having a small electric motor supply the power for adjustment of the potentiometer, the direction in which the power is exerted being controlled by the position of the galvanometer needle. Instruments suitable for recording the temperatures of a number of couples simultaneously are in successful operation in a number of large electrical installations. Fig. 5 shows a record obtained from a recording instrument of this kind.

The operation of the electrical resistance thermometer is based on the principle that the electrical resistance of a pure metal changes in a definite manner with its temperature, and a curve can be plotted between its unit resistance in ohms and its temperature. With the aid of such a curve the temperature of a metal can be determined from its unit resistance and vice versa. Base upon this, a resistance-measuring instrument may be calibrated to measure this change in resistance, not in electrical units, but in terms of the corresponding temperature. A resistance detector, therefore, consists of a resistance unit or coil and the measuring instruments.

A resistance unit such as is shown in Fig. 6, consists of a coil of very fine wire wound non-inductive; that is, the two halves of the coil are wound in opposite directions. As it has to be placed in the winding of the electrical machine, where space is valuable, it is necessary to make it thin, the total thickness not exceeding $\frac{1}{16}$ in. The length of the coil itself must be limited to a

space just sufficient to give the detector coil its proper resistance, as only a short coil placed in the hot spot of a winding records the temperature of the latter.

The principle upon which the indicating instrument shown in Fig. 7 is constructed, is that of a Wheatstone bridge combined with a differential voltmeter. This instrument requires an auxiliary source of electromotive force. In Fig. 7 C is the temperature detector, G_1 and G_2 the two coils in the differential voltmeter, R resistance forming part of the voltmeter and serving to adjust its deflector range, R_2 and R_3 are auxiliary resistances in the supply circuit. When the resistance of the two circuits G_1L_1C and G_2RL_2 are alike, currents of equal value flow in the coils G_1 and G_2 and the needle of the differential voltmeter remains in its middle position. With an increase in the temperature of C its resistance increases and the current in G_1L_1C decreases as compared to the current in G_2RL_2. Consequently, G_2 develops a greater pull than G_1 and registers a deflection on the voltmeter scale proportional to the temperature increase of C. As the deflection of the voltmeter depends on the temperature of C, it can be calibrated to record the coil temperature directly.

If the leads L_1 and L_2 between the temperature coils and the indicating instruments are similar in length, section and material, the influence of the one upon the readings of the instruments approximately compensates that of the other.

In the main supply circuits the value of the resistances R_2 and R_3 is a function of the voltage of the latter and limits the instrument current to its proper value. Fluctuations of the supply voltage react upon the accuracy of the meter readings. Small fluctuations are not important, but sources where large fluctuations occur are unsuitable for this class of service. Instruments of this type properly installed will indicate the detector temperature directly. The indicator may be mounted on the switchboard panel together with the other instruments or on a special panel near the machine whose temperatures it indicates. Fig. 9 is a wiring diagram for an indicator suitable for reading the temperature of any one of six embedded resistance detectors. The leads from the detectors are brought outside the machine to a terminal board from where connections are made to the instrument. As a safety measure against accidental high voltage, film cutouts are provided on the terminal board of the generator. Special care should be exercised to protect this type of installation against stray currents and leakage.

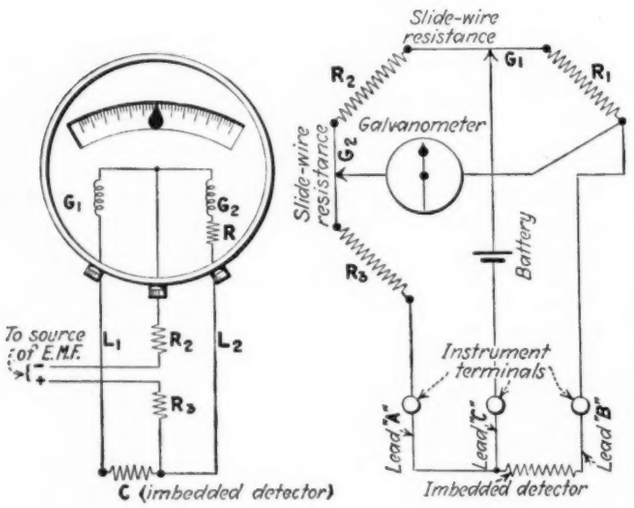


FIG. 7 FIG. 8

FIGS. 7 AND 8. DIAGRAMS OF INSTRUMENTS OPERATING ON WHEATSTONE-BRIDGE PRINCIPLE

In installations where no constant source of direct current is available or where occasional checks on the machine temperatures are sufficient, the self-contained instrument shown diagrammatically in Fig. 8 is frequently used in preference to the direct-reading, indicating instrument. This instrument operates on the principle of a modified Wheatstone bridge. The embedded resistance detectors are connected to the terminals of the instrument by means of leads A, B and C. The instrument contains a galvanometer and a battery supplying the necessary operating current. In addition to the three fixed resistances, R_1, R_2, R_3, two slide-wire resistances with adjustable contacts, G_1 and G_2, are adjusted until the galvanometer shows a balance, and at this point the scale on the turning knob gives the temperature of C. The length, section and material of leads A and B must be similar, as otherwise they introduce inaccuracies.

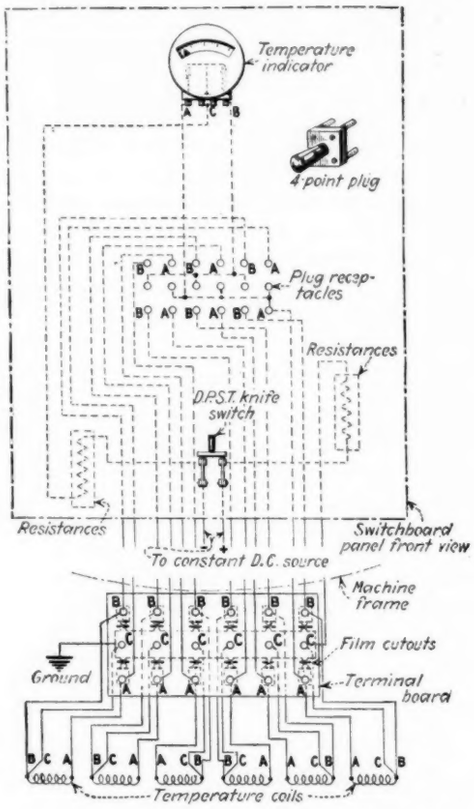


FIG. 9. WIRING DIAGRAM OF INSTRUMENT INDICATING TEMPERATURES OF SIX EMBEDDED DETECTORS

Graphic instruments suitable for operating in conjunction with a number of resistance detectors are in successful operation in a number of large power stations where a permanent record of the operating temperatures is of importance. Where accurate temperature records are available it is possible to determine the general condition of the machine. If, as an example, its ventilating ducts need cleaning, this will be indicated by an increase in its operating temperature. It is also possible to adjust the load to correspond to variations in the ambient temperature of the ventilating air.

Why Fuel Oil Must Continue to Compete with Coal

By E. J. BILLINGS
Henry L. Doherty and Company

SO LONG as the demand for gasoline requires the "topping" of more crude oil than would normally be needed for the production of fuel oil, the latter must continue to be a byproduct sold at a price to meet the competition of coal. Fair comparison of fuel oil with coal cannot be made on the basis of B.t.u. alone. Allowance must be made for higher efficiency and reduced operating expenses. Should changed price relations make it desirable to shift back to coal, the oil-burning investment is not wasted because it insures against coal shortage and makes it possible to profit by "soft spots" in the fuel-oil market.

FUEL oil in many localities is still cheaper than coal, and a question that is puzzling many a prospective user of fuel oil is that of the adequacy of the supply and the trend of prices. Will he be warranted in going to the expense of equipping his boiler plant for burning fuel oil in order to take advantage of the present situation in the fuel-oil market, or is fuel oil likely to go suddenly "skyrocketing" in price and then disappear from the market altogether, leaving him with oil-burning equipment on hand not yet paid for out of the savings? Brief mention of some of the important factors is all that is attempted in this discussion.

A popular opinion frequently expressed is to the effect that the quantity of fuel oil produced is growing less with the adoption of modern refinery methods and that it is about to disappear from the market as a competitor of coal. While it is true that larger percentages of gasoline are being extracted from the crude oil in modern refinery processes, it is also true that the majority of simple topping or skimming plants still continue to operate, presumably at a profit, and will in all probability continue to do so as long as the prices of crude oil and petroleum products stay within the range of prices established during recent years. As long as these skimming or topping refineries can operate, fuel oil will be produced.

Oil Production and Consumption Increasing

The accompanying tables submitted by the United States Bureau of Mines show that during the last five years in the United States fuel and gas oil has been produced in larger quantities in each succeeding year, and that the third quarter of the year 1921 shows a larger production, a larger consumption and greater amounts in storage than at any time during the period. Throughout this period gasoline consumption has increased beyond any figures yet encountered, and with anything like a normal return to business activity, more crude oil will have to be run in order to produce the gasoline requirements. This means continued increase in the amount of fuel oil available for industry.

Fuel oil may be considered as a byproduct from the manufacture of gasoline and other petroleum products, and as such it is not always produced where the best markets for it exist nor in quantities regulated only by the demand. It must, broadly speaking, be sold in competition with coal. The price obtained for fuel oil in order that it may be marketed can exceed only temporarily, if at all, the corresponding price for coal, and it may be a great deal less, depending on the quantity to be marketed and the absorbing power of the market. The high prices of fuel oil during the early part of 1920 are fresh in our minds. This situation was due largely to a disturbed coal-market condition and the uncertainty of being able to buy coal at any price. It is hardly to be expected that these prices for fuel oil will be duplicated except under coal-market conditions that are similarly strenuous. The high prices of 1917 and 1918 were due very largely to the war activities and their relations to the general fuel-supply situation.

Fuel Oil Must Meet Competition of Coal

There are a number of industrial applications of fuel oil where coal is not competitive, such as in certain metallurgical operations, but the total requirements for these purposes is a negligible factor in regulating the price of fuel oil. A factor contributing to this condition is the increasing use of coke-oven or manufactured gas and powdered coal in industrial applications formerly requiring natural gas or fuel oil.

The railroads of the United States, according to the American Petroleum Institute's statistics, used in 1920

ANNUAL PRODUCTION OF FUEL AND GAS OIL IN THE UNITED STATES

U. S. Bureau of Mines

1916	102,100,000 barrels
1917	155,000,000 barrels
1918	174,319,000 barrels
1919	181,600,000 barrels
1920	210,960,000 barrels
1921*	228,500,000 barrels

* Based on first eleven months of year.

STOCKS OF FUEL AND GAS OIL ON HAND

December 31, 1916	17,100,000 barrels
December 31, 1917	13,740,000 barrels
December 31, 1918	15,700,000 barrels
December 31, 1919	17,000,000 barrels
December 31, 1920	19,940,000 barrels
November 30, 1921	30,463,000 barrels

AVERAGE MONTHLY CONSUMPTION OF FUEL AND GAS OIL

1917	13,280,000 barrels
1918	15,200,000 barrels
1919	14,942,000 barrels
1920	17,335,000 barrels
1921*	18,087,000 barrels

* Average for first eleven months of year.

as locomotive fuel approximately 43,000,000 bbl. of fuel oil, of which practically one-half was used by the Pacific Coast lines. While fuel oil for locomotive use is strictly competitive with coal, the extent to which the railroad requirements dominate the price of fuel oil is not great, as is evidenced by the quantity used.

It is true that fuel oil has made great strides in replacing coal in marine operations, and on account of certain peculiar advantages, chiefly that of a saving in bunker space, fuel oil can be sold at a higher price in comparison with coal than in land competition. The

deliveries of fuel oil to the United States Navy and merchant vessels for the year 1920 totaled 45,000,000 barrels, and probably more than one-half of this amount was obtained from Mexican crude because of its availability at tidewater points and at comparatively low prices. As long as this condition exists regarding the use of Mexican fuel oil, there is but little chance that the marine requirements will materially affect the disposal of the fuel-oil output of inland refineries.

The Mexican Situation

Much has appeared recently in the newspapers regarding the Mexican situation, but the actual facts are difficult to obtain. Despite all predictions to the contrary, Mexico is now exporting more petroleum than ever before in its history, and the daily press is still chronicling the bringing in of large producing wells from the present known fields and extensions. The tax situation that has also taken up so much space, while apparently not settled, should not prove a serious obstacle to the use of Mexican fuel oil, for the reason that the slight increase in tax which has been mentioned, of from five to ten cents per barrel, will still permit this oil to be purchased and used on a fairly competitive basis with coal. In this connection, also, fuel oil users must not overlook the fact that oil development is going on in almost every part of the world and as domestic and foreign comsumption increases, oil will undoubtedly be added to the world's known production from some of these sources.

The prospective fuel-oil user may rest assured that there are going to be large quantities of fuel oil produced in the United States for some time to come and that the price will be determined largely by the price of the coal with which it is in competition. In periods of over-production, as at the present time, there will be a "soft" fuel-oil market. A contract for fuel oil with a good reliable producing company will be a guaranty as to supply and price, and if the user is not unfavorably situated with regard to a refinery center the odds are very much in favor of his being able to make continued and satisfactory renewals of his contracts.

Much information is available regarding the probable boiler efficiencies with and the cost of installing fuel-oil burning equipment. In fact, the art of burning fuel oil is over twenty-five years old, and the practice today is fairly well standardized. In making up the plans and estimates for any specific job, however, there are certain essential features that should be borne in mind.

Technical Considerations

A highly important feature from the point of view of efficiency is that of furnace design. It is quite essential for maximum boiler efficiency that combustion be practically completed before the gases come in contact with the cool surfaces of the boiler. This necessitates ample room for flame travel and a combustion space of not less than fifty and preferably sixty-five cubic feet or more if possible per thousand pounds of steam produced per hour. There is usually sufficient combustion space allowed by simply removing the stoker or grate, but if this is not the case it will be advisable to adopt one of the several devices for adding to this space, such as removing the bridge wall and firing from the rear or deepening the ashpit or putting on a dutch oven. Occasionally, it is possible, or necessary in spite of a loss in efficiency, to install the burners over the grates or stokers, leaving the latter intact for conversion to coal burning on short notice. In such a case the stoker or grate is covered over with a refractory material and air infiltration reduced to a minimum.

Burners Should Be Carefully Installed

There are a number of well-known makes of burners on the market, and if one of these is chosen, there is not much chance of going wrong on this score. It is very essential, however, that the burner be properly installed as to position in the furnace and that an adequate and properly distributed air supply be provided. If more than one burner is used per boiler, it is quite desirable that the air supply be regulated independently to each burner so that one burner and its corresponding air supply can be shut off simultaneously, thereby making it possible to reduce the steaming capacity of the boiler without over-ventilation of the furnace. Tight-fitting boiler dampers are particularly essential with fuel oil since with the latter it is possible to reduce the consumption of fuel on banked boilers far below that used in coal firing.

Satisfactory pump, heater and regulator sets have been manufactured for years by several reliable concerns and there should be no difficulty encountered in obtaining suitable equipment. There should be a spare oil pump available at all times for use in case of emergency. The heater should be of ample capacity to heat the oil to the proper temperature as determined by the specific gravity of the oil and the type of burner used.

The location, size, type and cost of the fuel-oil storage capacity will depend almost entirely on local conditions. Ordinarily, a two-weeks', and preferably a month's supply, should be maintained at the plant. At the present time oil-storage capacity in steel tanks above ground may be provided at a moderate expense.

If the efficiency of the boilers using coal is known, it will not be difficult to estimate the number of barrels of oil that will be the steam-producing equivalent of a ton of coal. This may ordinarily be expected to run somewhere between three and four barrels of oil per ton, depending on the grade of coal used and conditions bearing on efficiency with both coal and oil. Calculations for each individual case are preferable to the use of tables, charts or other short cuts, although these have a limited value for checking purposes.

Other Savings by Using Fuel Oil

Fuel and payroll savings will constitute the greater portion of the total savings due to the use of fuel oil, but the savings should not be overlooked on such items as disposal of ashes, maintenance of stokers, stoker engines and coal- and ash-handling equipment, steam or power for stoker and coal- and ash-handling auxiliary drives, deterioration of coal-pile and other miscellaneous items that may appear in individual cases. The added boiler capacity available with oil firing will have a cash-saving value in many cases. The cost of steam for atomizing, pumping and heating the fuel oil will have to be subtracted from the gross savings, but the quantity of steam required should not, under ordinary circumstances, exceed from 3 to 5 per cent of the total steam produced.

The investment in oil-burning equipment may in most cases be considered permanent. A very large proportion of the industrial plants in the United States that

are using fuel oil under steam boilers today have been using it for years and will, in all probability, continue to do so. If, on account of a higher price for fuel oil, it is found expedient to return to coal firing, the investment in oil-burning equipment will continue to prove useful as a means for maintaining an auxiliary fuel supply ready for emergency use without the storage losses common to coal. Moreover, the equipment will be available for use at a later date under price conditions more favorable to fuel oil.

After fuel-oil-burning equipment has been put in service, the owner will wish to make occasional comparisons between his actual steam-producing costs and what they would have been had be been using coal. In order to avoid a premature conversion back to coal, even greater care is necessary in calculating and including all the savings due to fuel oil than when the reverse conversion was under consideration. Oil as a fuel has every natural advantage in its favor, and all savings that are actually realized should be taken into account in order that the ideal boiler-plant conditions obtained may be continued to the profit of the owner and the satisfaction of the operators.

United Machine Stoker Embodies Special Features

While the "Industrial Stoker," recently designed and put on the market by the United Machine and Manufacturing Co., of Canton, Ohio, is not a radical departure from present practice, it incorporates several features not previously applied to this type of stoker.

Probably the most important of these features is one allowing for independent control of the air supply to the

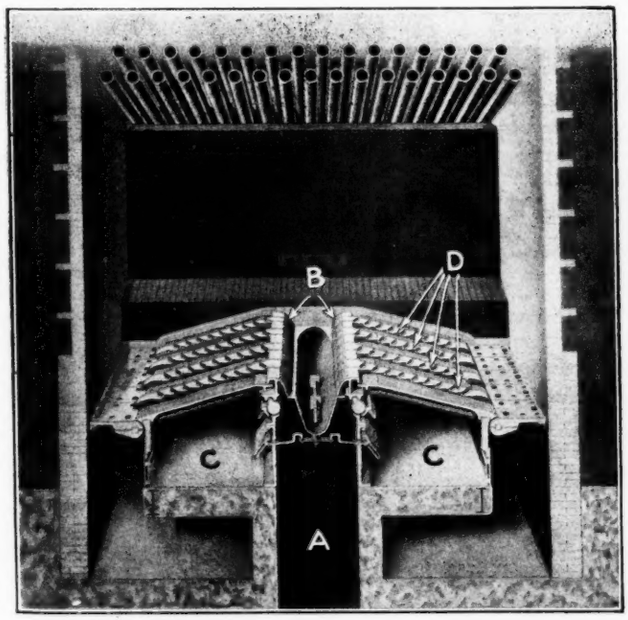


FIG. 1. DAMPERS ALLOW INDEPENDENT CONTROL OF AIR TO CENTER AND SIDES OF FIRE

thick central part of the fire and to the thinner parts at the sides. This is shown in Fig. 1, in which may be seen the central, high-pressure air duct *A*, which is directly under the retort and feeds air through the perforated tuyere heads *B*, into the thickest part of the fire. On both sides of this central duct are secondary chambers *CC*, into which air passes from the central duct, in the quantity desired, through the dampers, which may also be seen in the illustration. The air then goes to the fire on each side through holes in the stepped grate bars *D*. Thus it should be easy to maintain the

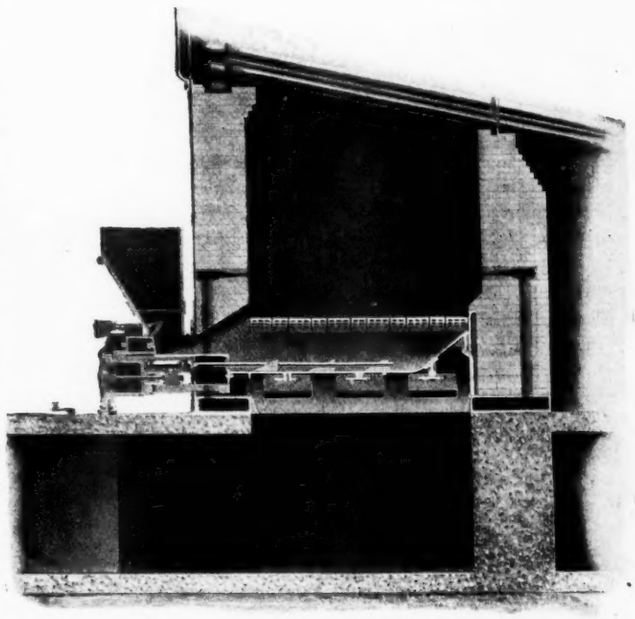


FIG. 2. LENGTHWISE SECTION OF STOKER, SHOWING RAM MECHANISM AND AIR DUCT

best proportion between the air supplied to the center and to the sides of the fire, by proper adjustment of these dampers.

Operation is much the same as in other stokers of this type, the coal being fed into the hopper shown in Fig. 2, pushed into the retort by the ram and shoved along toward the rear by the auxiliary pushers on the bottom of the retort. To keep the coal agitated in this part of the stoker, the whole row of tuyeres *B* on each side of the retort is moved back and forth horizontally, at right angles with the retort, by the rocker bars that may be seen just above the dampers in Fig. 1. Alternate tuyeres are in one piece with the stepped grate bars *D*, which therefore move back and forth with the tuyeres. The other grate bars are separate and so remain stationary. The result of this movement, of course, is that the burning coal gradually slides down the inclined grate toward the dump bars.

While the stepped grate bars and the tuyeres normally move simultaneously with the ram, the latter may be operated alone whenever necessary. The grate bars, the tuyeres and the ram are also readily adjustable for length of stroke and speed.

An auxiliary air supply is provided by openings in the furnace walls. They may be seen in the middle of the bridge wall in Fig. 1 and in section in Fig. 2.

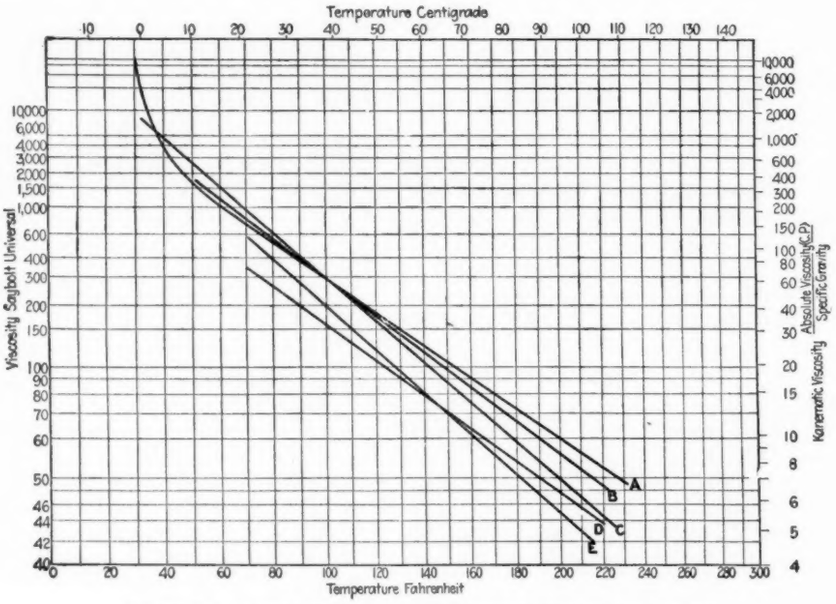
Operation of the stoker is automatically controlled for varying loads by a regulator valve and oil system.

The new 300,000-kw. Hell Gate Station of the United Electric Light and Power Co., New York City, which is now being put into service, will be completely described in an early issue of *Power*.

How Variation of Temperature Affects Viscosity of Lubricating Oils

By W. F. OSBORNE*

EVERYONE knows that when oil is heated it gets thin and that when it is cooled it gets thick, but we are not all quite so familiar with the fact that all other liquids do likewise. For instance, water at 195 deg. F. is less than one-fourth as viscous as it is at 50 deg. The reason the difference in oils is so noticeable is that oils are thick to begin with and, furthermore, the rate of change is much more rapid than with water. The chart shows how the viscosities of lubricating oils vary with the temperature. On this account, when taking viscosities of such oils it is always necessary to specify the temperature at which the viscosity was measured in order that true comparisons can be made. Standard temperatures accepted for viscosity readings are: Turbine, engine and machine oils, 100 deg. F.; steam-cylinder, car oils and gear oils, 210 deg.; motor oils for internal-combustion cylinders, 100 or 210 deg. The rate of change of viscosity varies with different oils and depends on the character of the hydrocarbons from which the oil is made. From the temperature-viscosity chart it will be noticed that the curves for some oils are much flatter than those for others.



VISCOSITY VARIATION WITH TEMPERATURE CHANGES

Oils *A*, *B* and *C* shown in the chart have exactly the same Saybolt viscosity at 100 deg. F. At 150 deg., however, oil *A* has a viscosity of 105 seconds, oil *B* a viscosity of 98 and oil *C* a viscosity of 87.5 seconds Saybolt. In other words, as it is heated, oil *A* thins down less rapidly than does oil *C*. Whether this is a desirable characteristic depends entirely upon the purpose for which the oil is to be used, and is a matter that can be determined only when the range of operating temperatures under which it is proposed to use the oil is known.

Turning now to the other end of the curve, as oil *A* is cooled to 50 deg. F., its viscosity rises to about 1,600 Saybolt, oil *B* to 1,900 and oil *C* to 2,800 seconds. This is quite in accordance with the way the viscosity changed above 100 deg. F.

When the oils are cooled still further, a peculiar thing occurs: The viscosity of oil *C* continues to rise in a straight line. Oils *A* and *B* curve sharply upward and the lines of *C* and *A* cross at 36 deg. F., at which temperature they have a viscosity of 7,000 Saybolt. Oil *A* now rapidly increases in viscosity and at 30 deg. F. becomes practically solid, while oil *C* continues to remain liquid until a temperature of 0 deg. F. is reached.

This rapid increase in the viscosity of oil *A* is caused by a partial solidification of the paraffin wax which it carries in solution, and as the oil is cooled to its pour test, the wax separates and raises the viscosity very rapidly. Oil *C* contains no paraffin and does not solidify until a much lower temperature is reached. Oil *C* is a straight naphthene-base oil, oil *A* a straight paraffin oil and oil *B* is a blend of the two, being a light-viscosity naphthene-base oil to which a paraffin cylinder oil has been blended to raise the viscosity. Both flat-slope and steep-slope oils have distinct advantages for certain purposes, which will be brought out in the later articles of this series. On account of the fact that all oils do not change in viscosity at the same rate, it is particularly important to determine the actual temperature under which the oil is to be used and the viscosity of the oil at that temperature, when making selections or recommendations of lubricating oils.

Lubricating oils are purchased on a basis of certain viscosity at 100 deg. F., as it is necessary to have some temperature at which manufacture can be standardized. But knowing the viscosity of the oil at 100 deg. F. does not always enable the engineer to know the viscosity at some other temperature, as may be seen from the different viscosity slopes. Therefore, the engineer should always carefully determine as accurately as possible the operating temperature and then select the lubricating oil that will have the right viscosity at that temperature.

Q. I find that a 28 Bé. gravity oil of 160 seconds Saybolt viscosity gives very satisfactory results in my turbine with a bearing temperature of 160 deg. F. What viscosity should I specify for an oil of 21 Bé. gravity in order to get the same results?

A. An oil of 160 seconds Saybolt viscosity and 28 Bé.

*Supervisor Manufacturers' Service, Texas company.

gravity has a Saybolt viscosity at 160 deg. F. of 64 seconds. This is equivalent to a kinematic viscosity of 10.7 centipoises and an absolute viscosity of 10.7 × 0.8511 (the specific gravity at 160 deg. F.) which is equal to 9.097 centipoises. The 21 gravity oil must have exactly the same absolute viscosity at 160 deg. F. in order to produce the same bearing temperatures, neglecting the difference in specific heat.

A 21 gravity oil has a specific gravity at 160 deg. F. of 0.8917. Its kinematic viscosity therefore must be 9.097 ÷ 0.8917 = 10.2 centipoises which is equivalent to a Saybolt viscosity of 61.5 seconds. A 21 Bé. gravity oil having a Saybolt viscosity of 61.5 at 160 deg. F. will have a viscosity at 100 deg. F. of 200 seconds Saybolt.

These figures are reasonably accurate for non-blended oils; that is, for straight-run oils made from the crudes which will give the gravities referred to.

Your specification should therefore call for a 28 Bé. gravity oil of 160 Saybolt and a 21 Bé. gravity oil of 200 seconds Saybolt at 100 deg. F. and the results in the turbine bearings will be exactly the same. However, if the operating temperature of the bearing should change for any reason whatever, these viscosity relations will have to be adjusted again.

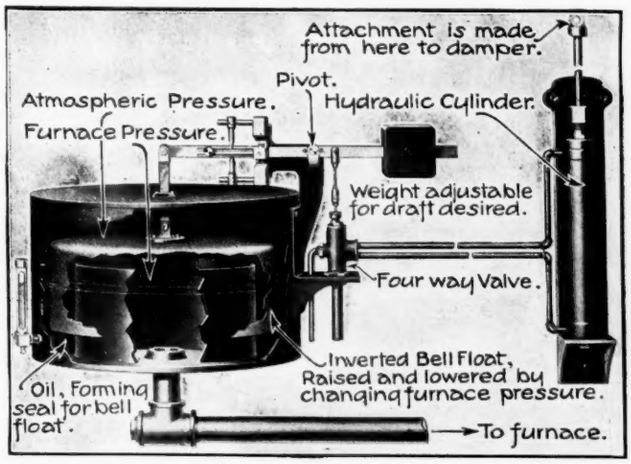
New Carrick Regulator Operated by Draft

For a number of years the Carrick Engineering Co., of Chicago, has manufactured an automatic furnace regulator that is operated by changes in steam pressure, varying the fuel feed and damper position according to the pressure. Now the company has added to its line a regulator of the so-called gasometer type, which depends for its operation upon the furnace draft. The steam-pressure system generally consisted of a master regulator governing the operation of auxiliary regulators at each boiler for controlling all boilers as a unit, with attachments to the stoker and fan drives for simultaneous control. The new draft-operated device was designed principally for use in connection with forced-draft stoker installations for controlling each boiler individually, and may be used either in combination with the other system or independently.

The manufacturers advise the use of the two types of apparatus in combination. In such cases, the master pressure-operated regulator is arranged to control simultaneously the breeching dampers and the stoker drives of all the boilers, while a gasometer on each boiler controls the air supply to the individual furnace, according to the draft. Thus, the breeching dampers and the stoker drives are adjusted automatically to meet changes in steam pressure or load, while the individual gasometer regulators, operated by changes in the furnace draft, take care of the variations in fuel-bed resistance in the different furnaces, reducing the air supply to a thin fire and increasing it to a thick fire.

The principle of operation of the new draft-operated device may be seen in the illustration. At the right is the hydraulic cylinder, in which a piston moves up and down and does the actual work of setting the damper. This piston is moved by water that is admitted at either the top or the bottom of the cylinder according to the movement of the four-way valve. This valve is operated by the horizontal lever, the other end of which is attached to the inverted bell float, which rises or falls according as the pressure in the furnace increases or decreases. The action of this float may be regulated by moving the counterweight in or out on the end of the horizontal lever, thus setting the device for the desired furnace pressure. (Furnace pressure here means absolute pressure, for it may of course be below, at or above atmospheric.)

In operation a decrease in pressure over the fire allows the bell float to fall slightly, thus lifting the rod in the four-way valve, which allows water to pass through the upper of the two pipes into the top end of the hydraulic cylinder, forcing the piston down in the cylinder. This downward movement of the piston either operates a damper, tending to close off the breeching, or else it increases the forced-draft supply, according to whether the device is being used independently or in combination with the steam-pressure system. An


Attachment is made from here to damper.
Pivot.
Atmospheric Pressure.
Hydraulic Cylinder.
Furnace Pressure.
Weight adjustable for draft desired.
Four way Valve.
Inverted Bell Float, Raised and lowered by changing furnace pressure.
Oil, Forming seal for bell float.
To furnace.

THE NEW DRAFT-CONTROLLED FURNACE REGULATOR

increase in furnace pressure raises the bell float and reverses the operation, opening the air-supply dampers.

It is claimed by the makers that the oil in the body of the regulator acts as a dash-pot and so prevents hunting action. It is pointed out also that in case of excessive pressure in the furnace, this oil seal prevents the furnace gases from blowing out.

When Is Oil Good?

"A petroleum product is good or poor only as it suits, or does not suit, the condition for which it is used." This sentence expresses the keynote of a paper read at the March meeting of the American Society of Lubrication Engineers, by William F. Parish, lubrication engineer.

He goes on as follows: "A watch oil may be exactly right for a watch; it will lubricate for years without evaporation; it is perfect for the purpose for which it is made. However, if this watch oil were put into the cylinders of a steam engine, it would fail to lubricate and would immediately become a 'poor oil,' not through any loss of intrinsic value, for it is still the 100 per cent watch oil, but through the fact that it was not being used under conditions suited to its nature." Similar illustrations were given of a good cylinder oil being used in a watch, a spindle oil being used on a stone crusher, fuel oil for engine bearings, etc.

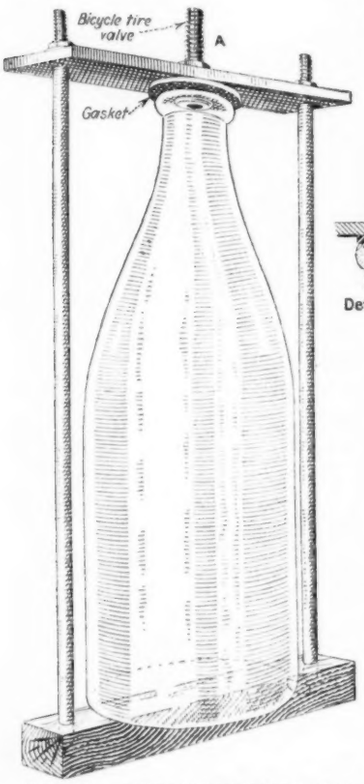
All these illustrations show clearly that an oil is not intrinsically good or bad, but is merely suited for some uses and not for others. It will always be rated as bad when given the wrong application.

Removing Boiler Scale with CO_2

Some Scales Removable by Carbonated Water—Work Done with Ordinary "Soda Fountain" Cylinders of Liquid Carbon Dioxide—Preliminary Tests Easy to Make

By R. J. CROSS and ROY IRVIN

AFTER trying to remove the scale accumulation from a battery of boilers by the usual method with little success, the authors decided to experiment with a solution of carbon dioxide in water. The success of the laboratory work and the subsequent tests on factory boilers led to a continuation of the investigation. While the experiments failed to develop a "cure all" for boiler troubles, the results presented in this report seem worthy of note as indicating what may be done in the case of certain troublesome scales. Fortunately, it is easy for the engineer to find out whether this treatment will be successful for his particular conditions without going to the expense of making a trial with the actual boilers. The effect of the treatment on a given scale can be determined by the apparatus shown in the figure. This consists of a heavy soda-water bottle equipped with an ordinary bicycle tire valve. The method of clamping indicated insures a tight joint and at the same time permits the valve to be removed in order that scale or water may be placed in the bottle or withdrawn.



BOTTLE ARRANGED FOR LABORATORY TREATMENT OF BOILER SCALE WITH CARBONATED WATER

In testing, a few fragments of scale were placed in the bottle and covered with water. The bottle was then closed and charged from an ordinary carbonating apparatus such as is used in connection with soda fountains. The pressure regulator was set so as to give a pressure of 70 lb. per sq.in. The action on the scale was observed from time to time, but it was ordinarily several days before marked disintegration of the scale became apparent. Little was gained in any case by continuing the treatment more than a week or ten days.

Further details of the experimental work will be given near the end of the article. For practical power-plant work it is sufficient to know that if the scale shows marked disintegration in the bottle, it may be expected that the gas treatment in the boiler will produce the same result.

After preliminary tests with the bottle experiments were made on two horizontal-return-tubular boilers supplied with feed water containing about 7 grains of total solids per gallon. The chemical composition of the solids were as follows: Silicon dioxide (SiO_2), 56.1 per cent; ferric oxide and alumina (R_2O_3), 0.58 per cent; calcium oxide (CaO), 6.98 per cent; magnesium oxide (MgO), 3.98 per cent. The scale was the result of years of accumulation. It was hard and very adherent, so that the air hammer and other methods of scale removal had little effect on it.

Little Scale Removed by Sal Soda and Lye

Before trying the carbonated water, an attempt was made to remove the scale by the use of a solution of sal soda and lye. One hundred pounds of sal soda and seventy pounds of lye were put in the boiler. It was then filled with water to the normal level and kept boiling for a week. The removal of a small amount of recently formed scale was accomplished by this treatment, but when it was repeated, some weeks later, no scale was removed.

Before beginning the carbon-dioxide treatment the blowoff pipe from the boiler was connected with the suction of one of the feed-water pumps. This pump then functioned as a circulating pump, withdrawing water from the rear of the boiler and discharging it into the front end. The boiler was cut out of service and allowed to cool with all exits closed. This was done so that it would be filled with boiled water free from dissolved gases. Cooling was facilitated by fitting temporary connections to several of the fire tubes and passing cold water through them.

Two cylinders of carbon dioxide, each containing about 50 lb. net, were emptied into the boiler through the discharge pipe from the circulating pump. The pressure gage on the boiler then showed 37 lb. The next day another full cylinder of gas was put in, and the gage showed 45 lb. pressure. The temperature of the water was 84 deg. F.

Gas Left in Boiler for Eight Days

The boiler was then allowed to stand eight days, by which time the pressure had fallen to 30 lb. It was then opened up, and the softened scale was knocked off with water from a high-pressure hose. The scale raked out of the manhole was found to weigh 287 lb. Almost half the surface of the boiler was free from scale and rust, and the exposed surface had the blue color of new tubes.

After a week's service the boiler was again opened up, but no scale was found to have accumulated on the crown sheet. Similar treatment was given to another boiler of the same battery with practically the same results. About a year later it was found possible to cut the boilers out of service, so the treatment was repeated

*A contribution from the Mellon Institute of Industrial Research, of the University of Pittsburgh, Pittsburgh, Pa.

on both. This time, more than 100 lb. of scale was removed from each boiler, after which they were practically free from scale.

The experiments indicate that carbon dioxide in water is a solvent for certain boiler scales that are high in lime and silica and comparatively low in carbonate. The use of this treatment is advocated only after laboratory tests (by the "soda-water bottle" method) have shown that it is applicable to the case under consideration.

In applying this method, it is important to have all joints and valves absolutely tight to prevent the loss of carbon dioxide. However, small leaks in the main stop valves of the steam lines will do no harm if steam pressure (from other boilers) is on the line. This will prevent any outward leak.

Additional Data

For the benefit of those who are particularly interested in the chemistry of this process, the following additional test results are given. The accompanying table shows the chemical analysis of five different samples of scale, upon which the carbonated water showed (in the laboratory tests) a marked disintegrating effect.

The samples of scale shown in the table, except No. 2, were taken from boilers in different localities, twenty to one hundred miles apart. Samples Nos. 1 and 2 were

ANALYSIS OF SCALE SAMPLES THAT GAVE FAVORABLE RESULTS IN LABORATORY TESTS WITH CARBONATED WATER

Sample No.	1	2	3	4	5
SiO_2 per cent	58.70	56.00	28.14	47.94	49.56
R_2O_3, per cent	1.90	1.90	2.68	5.02	5.30
CaO, per cent	26.08	23.30	36.62	29.44	27.42
MgO, per cent	2.98	3.53	1.96	3.11	2.66
Water at 230 deg. F., per cent	3.39	5.02	11.25	5.14	4.70
Ignition loss, per cent	7.07	10.65	0.92	8.58	9.17
SO_3	None	None	18.10	0.45	0.91
	100.12	100.40	99.67	99.68	99.72

from the same boiler, but No. 1 was taken before treatment with carbonated water, while No. 2 was the scale removed from the boiler by the treatment.

No tests were made on the boilers represented by the samples Nos. 3, 4 and 5, but the bottle test indicated that the process would have been as successful as in the case previously described. All boilers represented by samples whose analyses are shown had a history of gradual accumulation of scale, and it was said that in each instance several well-known brands of boiler compound have been used with negative results. Sample No. 5 contained a small amount of graphite, which came from a boiler compound previously used.

None of the samples showed effervescence when a lump was treated with hydrochloric acid, but the powdered scale did give slight effervescence. A considerable number of high-carbonate scales (showing strong effervescence when a lump was immersed in hydrochloric acid) were submitted to the action of the carbonated water, but in none was there marked disintegration of the scale.

Attempts were made to extend the application of the process by adding some other substance to the carbonated water. Ammonium chloride, sodium bicarbonate, sodium phosphate, ammonium tartrate, potassium fluoride and ammonium fluoride were tried, but none of these yielded results worthy of note.

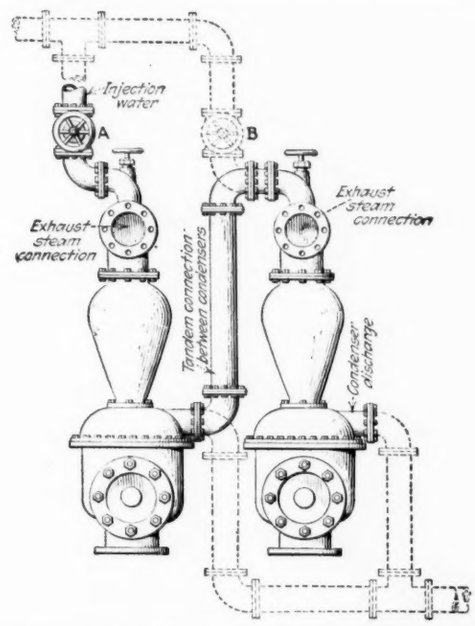
In the selection of gage glasses it is not necessary to pick out the ones with the heaviest walls, for those with slightly lighter walls are as strong and will last as long as the thicker ones.—*The Locomotive.*

A Pair of Jet Condensers Arranged in Tandem

By A. J. Dixon

The accompanying sketch shows how a pair of second-hand jet condensers of about 400-hp. capacity each were rigged up for condensing the exhaust from an 800-hp. engine. A branch from the main exhaust pipe was connected to each condenser, so that it was expected that the exhaust steam would be divided equally between the two condensers. But with respect to the injection-water supply, the condensers were connected tandem fashion, so that the same current of injection water traversed both condensers.

This arrangement worked first rate after the engineer had learned how to regulate the injection-water valve and the gate valves in the two exhaust branches, to balance the work performed by the two condensers. But this required constant attention; The adjustments of the valves had to be changed frequently to preserve the same degree of vacuum in both condensers. If the adjustments were not watched critically, one condenser would show a higher vacuum than the other. Generally, when the work was thus unbalanced, the condenser that



PARALLEL CONNECTION OF CONDENSERS FORMERLY ARRANGED IN SERIES, IMPROVES OPERATION

received the injection water first was the one that showed the higher vacuum.

From the early spring until the beginning of cold weather the condensers were operated in this way. The engine was then run non-condensing to supply exhaust steam for heating. This gave the engineer a chance to improve the installation by connecting each condenser independently to the injection and discharge lines, as indicated by the dotted lines in the accompanying sketch.

When condensing operation was resumed in the following spring, the condensers could be worked with the gate valves in the exhaust branches wide open. The only attention needed was an occasional adjustment of the two injection water valves *A* and *B*, shown in the illustration.

The Point of Release on the Indicator Diagram

Complete Expansion Cannot Be Secured—Exhaust Valves Should Open Before the End of the Stroke—No Practical Loss of Energy Occurs with Early Release

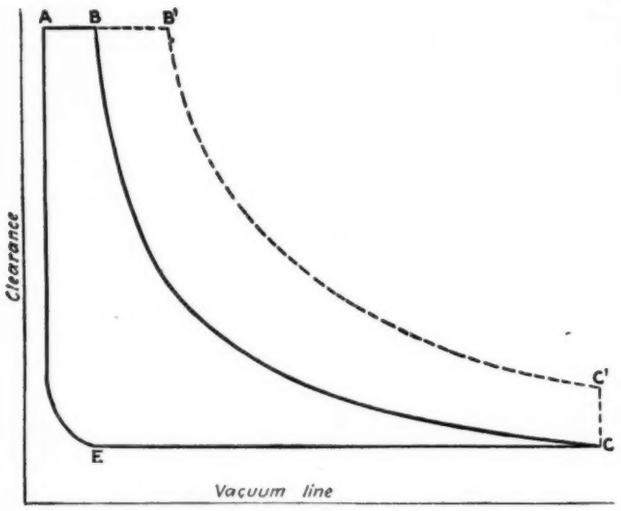


FIG. 1. RELEASE WITH COMPLETE EXPANSION

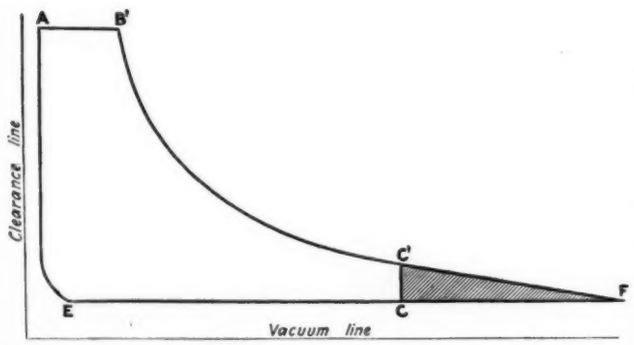


FIG. 2. ENERGY LOSS WITH INCOMPLETE EXPANSION

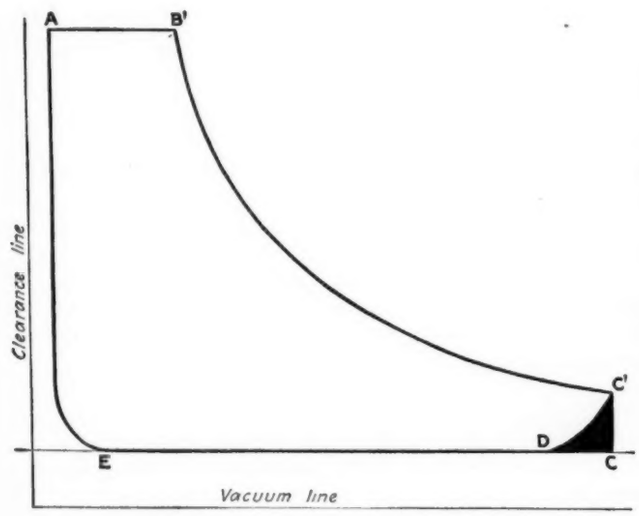


FIG. 3. BACK-PRESSURE LOSS WITH LATE RELEASE

THE ideal expansion curve would be one in which the steam in the cylinder expands until it reaches a pressure equal to that existing in the exhaust line. To do this, with an initial pressure of 100 lb. gage (114.7 lb. absolute) would require a ratio of expansion of $\frac{114.7}{14.7}$, or 7.8, and the indicator diagram from the engine would appear similar to Fig. 1, where, assuming a 4 per cent clearance volume and 100 lb. gage initial pressure, cutoff takes place at B and the expansion ends at C with a final pressure equal to the atmospheric, the engine operating non-condensing.

This diagram is very thin, owing to the large expansion, and as a result the average pressure exerted on the piston during the stroke is by no means large. The horsepower output will be small for a given cylinder volume. This is all the more true of a condensing engine operating with a back pressure below the atmosphere. If a 24-in. vacuum was carried, giving an absolute pressure of 2.93 lb. per sq.in. (—11.77 lb. gage), the expansion ratio would need be $\frac{114.7}{2.92} = 39.1$. The average pressure exerted on the piston and the horsepower would be totally out of proportion to the cylinder volume.

To increase the output per unit volume, the period of steam admission is prolonged and cutoff takes place, not at B but at B', Fig. 1. The expansion from B' to the final cylinder volume would give a final pressure at C' of 29.7 lb. absolute (15 lb. gage). The reader will see at once that the diagram area $AB'C'CEA$ is much larger than the complete expansion diagram $ABCEA$. A greater horsepower is secured from the same cylinder by using a longer cutoff even though this means a loss in energy due to stopping the expansion at 29.7 lb. This loss is shown in Fig. 2 to consist of the triangle $C'FC$.

If the exhaust valve opened at C', Fig. 1, and provided the piston speed of the engine was slow, the pressure would immediately drop from C' to C. But in an actual engine the area of the exhaust ports is not great enough to permit the passage of a large volume of steam during the small interval of time during which the piston reverses its stroke. With release at C' the pressure drop would continue after the piston had started on the return stroke, giving a curve from C' to D of the appearance of Fig. 3. The area $C'CD$ is lost, and the pressure in the end of the cylinder from which the diagram was taken exerted against the piston on its return stroke is not uniformly equal to the atmospheric, but from C to D is of a greater value. This condition is to be avoided since this area represents lost work of some magnitude.

When the piston approaches the end of its stroke at C' in Fig. 1, as will be discussed later the steam is trapped in the other end of the cylinder behind the

piston in order to supply a force to counteract the momentum of the moving parts at the point of reversal of the piston stroke. If the expansion is continued to C', the force acting upon the piston is the momentum

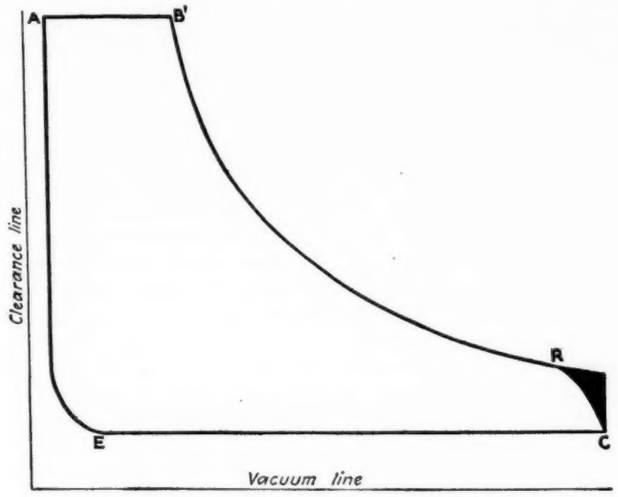


FIG. 4. EFFECT OF EARLY RELEASE

plus the pressure indicated by C'. By opening the exhaust valve at some point, as R in Fig. 4, the amount of pressure required on the other side of the piston for cushioning is reduced by an equal amount and no practical loss of energy occurs even though the black area is lost to the forward-stroke diagram.

Release at R has the extra advantage of allowing more time for the steam to pass out through the exhaust

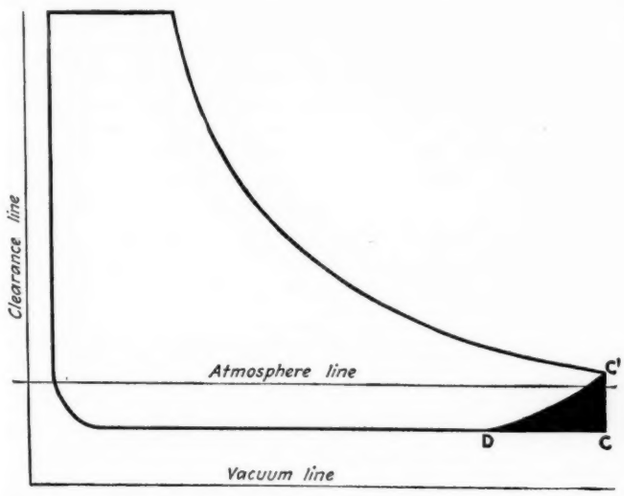


FIG. 5. LATE RELEASE WITH CONDENSING OPERATION

ports, and at C, the point of piston reversal, the cylinder pressure has reached that of the exhaust line.

If the engine is working condensing, the advantage of early release is enhanced, as will be apparent by a study of Figs. 5 and 6. In Fig. 5, by delaying the release until the end of the stroke, the black area $C'CD$ represents the additional resistance to be overcome by the piston after reversal. By early release at R, Fig. 6, the cylinder contents are expelled into the condenser and the load on the piston at once removed.

With a slide-valve engine the release may not be made very early. If the eccentric is advanced to give an early release, all the other events of compression, admission and cutoff are also made early. If the exhaust lap, Fig. 7, is cut away to cause the port to be uncovered early, the compression which is caused by the covering of the port on the reverse travel of the valve is made later since the valve must travel an additional amount before the port is covered exactly equal to the amount

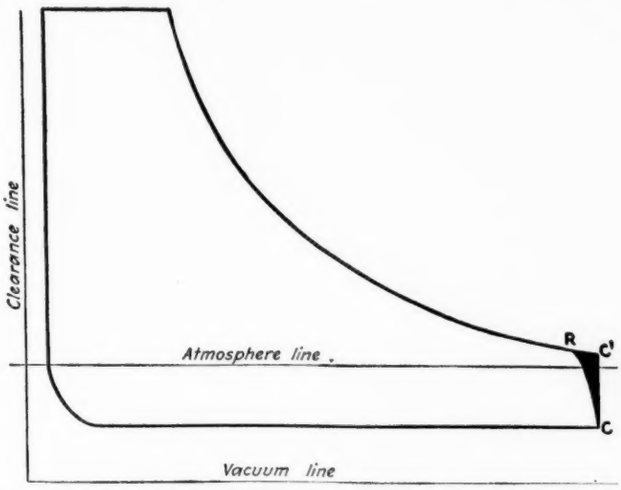


FIG. 6. EARLY RELEASE IN A CONDENSING ENGINE

of lap removed. Since compression must not be too late, the release cannot be made extremely early.

With a Corliss having a single eccentric, early release may be secured by advancing the eccentric, but this is limited owing to the fact that advancing the eccentric makes the range of cutoff less, which may be undesirable. The toe of the diagram, with the single-eccentric Corliss, usually has the appearance shown in Fig. 8.

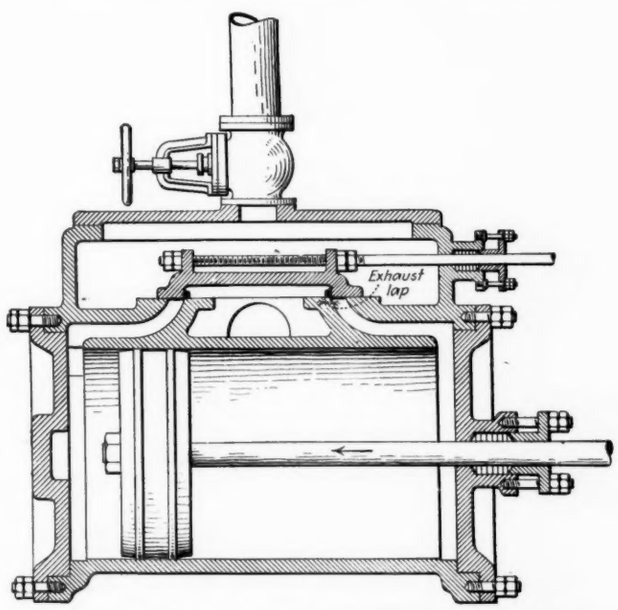


FIG. 7. EFFECT OF EARLY RELEASE WITH SLIDE-VALVE ENGINE

The unaflow engine expels the steam through a series of ports uncovered by the piston at about 10 per cent from the end of the stroke. Release with this type of engine is fixed by the location of the port and is more than ordinarily early, as indicated in Fig. 8. The com-

pression secured by the covering of these exhaust ports extends over nine-tenths of the return stroke. Upon release all the steam fed to the cylinder during the admission period must be expelled in the short period of time during which the piston, after uncovering the ports, moves to the end of the stroke and reversing covers the ports. For this reason the passage between the engine and condenser or the engine and the atmosphere should be short and practically free from pipe-line resistance. If the pressure in the cylinder at the time of port covering or beginning of compression is not approximately equal to the exhaust-line pressure, the final compression pressure may be excessive.

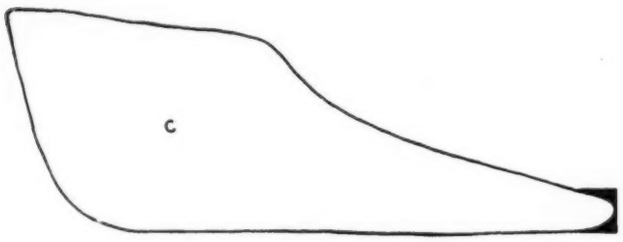


FIG. 8. RELEASE ON CORLISS ENGINE

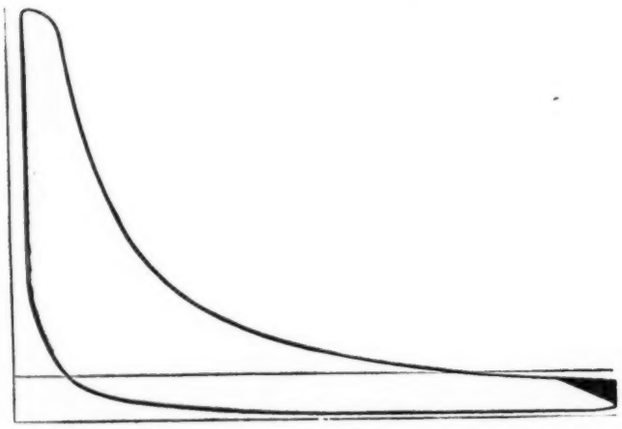


FIG. 9. PORT RELEASE ON UNAFLOW ENGINE

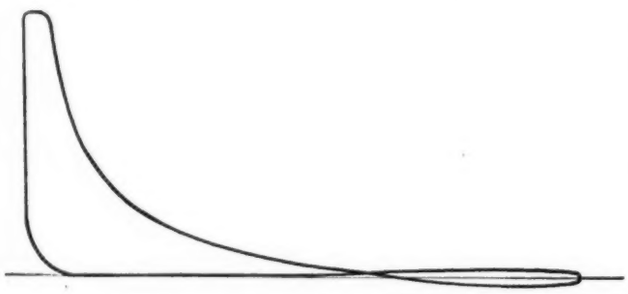


FIG. 10. EFFECT OF EARLY CUTOFF

With an early cutoff the rate of expansion may be such that the cylinder pressure falls below that of the exhaust line, assuming non-condensing operation. Immediately upon the opening of the exhaust valve, instead of the cylinder contents being expelled, the pressure in the exhaust line backs up, raising the pressure in the cylinder to that of the exhaust. On the return stroke the piston pushes out the cylinder contents at the exhaust-line pressure. This gives a toe of the shape indicated in Fig. 9. The loop represents negative work done and will be discussed in an article on measuring the diagram for the indicated horsepower. The expansion below the exhaust line pressure is the cause of valve slamming due to the exhaust-line pressure throwing the exhaust valve off from its seat.

Water Power in the Orient—Impressions from a Six Months' Tour

By W. M. White*

The Japanese are the most progressive people in the Orient, and it is interesting to note that they have developed more water power than all the other Oriental countries combined. It is estimated that the total available water power in Japan is about eight million horsepower and that at the present writing about one million horsepower has been developed and is in use, while another quarter of a million is in course of development. While there are several coal mines in Japan and in Manchuria, the price of coal is exceedingly high and the quality is not of the best, therefore water power has received more impetus than steam in those countries.

High Wage Dependent on Developed Power

An English statesman recently said in open Parliament meeting that the reason why American manufacturers can pay twice the rate of wage received by the English workman and yet compete successfully in the markets of the world, is because each American workman has behind him twice the developed horsepower per man that each British workman has to aid him. When this statement was called to the attention of the president of one of he largest water-power companies in Japan, he was able to furnish information that showed that each Japanese workman had behind him one-quarter of the horsepower per man that was available to the American workman, and that the rate of wage of the former was approximately one-quarter of that of the latter. The quantity of goods manufactured is roughly in proportion to the power expended in their production. It follows that the workmen who can direct and control the greatest amount of power per man are, by the inevitable law of competition, entitled to the greatest wage. The Japanese have developed their water powers during the last few years at a feverish rate, apparently realizing the necessity of more power for the greater prosperity of their country.

The comparison might well be carried a bit farther, when it is seen, in the case of China, where most of the work is done by hand, that the Chinese coolie receives only a few cents a day for doing work that is done here with an electric motor for about the same amount of money.

Greatest Developments Have Occurred Where Power Was Cheap

In looking back over the development of the United States during the last twenty years, the fact stands out that the greatest developments have occurred where the cheapest power was available. Examples of this are: The activities of the Southern Power Co. in and around Charlotte, N. C.; the Great Falls Power Co. around Great Falls, Mont.; the cheap power at Niagara Falls, which has resulted in the building of a large city within twenty years. The activities of the power companies on the Pacific Coast are well known.

*Manager and Chief Engineer, Hydraulic Department, Allis-Chalmers Manufacturing Co.

The Japanese are profiting by our experience, and are engaged in the broadest construction development of a country that has ever been undertaken. The Island of Formosa was ceded to Japan at the signing of the Shiminoseki Treaty in 1895. A recent visit through that island shows that remarkable progress has been made in its development during the last twenty-seven years. The Japanese have put into the island 1,000 miles of 42-in. gage standard railway and have practically built up Taihoku into a modern up-to-date city; but the greatest work yet projected for the island has just been undertaken—that of constructing a water-power plant near the outlet of Lake Jitsugetsutan at about the center of the island. The waters from the Dakusuikei River will be diverted through a 15-ft. tunnel ten miles long, and discharged into Lake Jitsugetsutan, which has a circumference of about ten miles.

The outlet from the lake will be impounded and the waters raised to an additional height of 85 ft. The water will be led from the lake through a tunnel 3½ miles long to a small reservoir, from which it will flow down a steep incline to the power house located on the banks of the Suirikei River. The head made available by these works is 1,000 ft. The discharge water from the power house flows into the Suirikei River, which finally joins the Dakusuikei River. It has been given out that contracts for the building of the electrical equipment have been let to a large electrical firm in this country, and that orders for the wheels have been placed with a German concern. The power-house equipment will consist of five units, each of 30,000-hp. capacity. The wheels will be of the impulse type. The copper has already been purchased for transmission lines leading from the most northern point to the opposite end of the island. It is planned to deliver 60 per cent of the power at Takiao, the southern city of the island and 40 per cent to the northern city of Taihoku.

The amount of power now used on the island is less than 10,000 kw. There is some coal mined in the vicinity of Taihoku, but it is of rather poor quality, averaging about 8,000 B.t.u. It is proposed to use this power for general industrial purposes and probably for the electrification of some of the railway lines. The orders for the machinery were placed during the Washington Conference, which should be sufficient evidence that the construction of the plant was not primarily for war purposes. The construction of power so much in excess of the present needs seems to be a most far-reaching move in the development of the country. The work is being financed by the Formosan government. With ourselves, there is still plenty of opportunity for a like work, since to date we have developed only about 15 per cent of the possible power available from water.

Load on Main-Bearing Caps of Horizontal Engines

BY W. TURNWALD

It is surprising to find that none of the engineering handbooks or textbooks makes reference to the very important subject of the load on the main-bearing caps of horizontal engines. As shown later, the load sustained by the cap is quite a large proportion of the piston load, and if no failures of this element are on record it is only due to the fact that a cap evidently does not look right unless it is strong enough.

In analyzing the load sustained by the main bearing cap, reference may be had to Fig. 1, which shows that starting with the piston load P, we obtain the connecting-rod force S by dividing P by cos β. The latter force we resolve into two components, one tangential to the crankpin and the other one P_c in the direction of the crank. This component is equal to $S \cos (\alpha - \beta)$ where α is the angle made by the pin and the horizontal plane, or $\frac{P}{\cos \alpha} \cos (\alpha - \beta)$. From this component we obtain the load L_c on the main-bearing cap, by multiplying it by sin α. Inserting the previous equations we finally obtain the formula,

$$L_c = \frac{P \cos (\alpha - \beta) \sin \alpha}{\cos \beta}$$

The curves given in Fig. 2 are based on this formula and show the load on the main-bearing cap for different

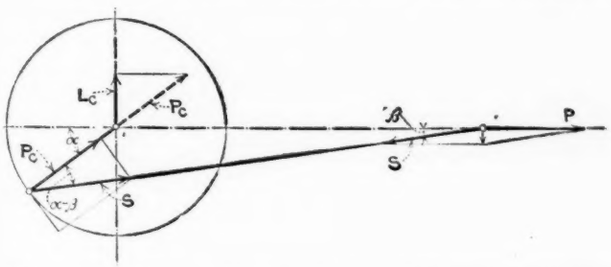


FIG. 1. DIRECTION OF FORCES IN HORIZONTAL ENGINE

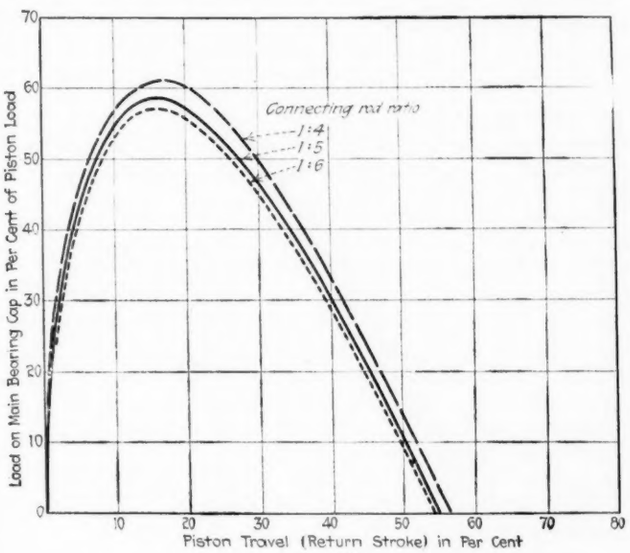


FIG. 2. BEARING LOADS DURING PISTON STROKE

connecting-rod ratios. The influence of the latter is negligible. The important point is that the main-bearing cap of the horizontal steam engine sustains a maximum load equal to about 60 per cent of the piston load. The fact, however, must not be lost sight of that that part of the weight of the flywheel, generator, armature and shaft which is supported by the main bearing relieves the cap by an equal amount, so that the actual loading is represented by the difference of the two forces.

Germany's exports in steam boilers are now two and one-half times what they were in 1913. This is a contrast to other power-plant machinery, which is only about one-quarter of the former figure.

Mean Temperature Difference

By H. L. DOOLITTLE
Assistant Construction Engineer, Southern California Edison Company

IN MAKING calculations regarding the transfer of heat in oil coolers and similar apparatus, it is necessary to know the mean or average difference of temperature between the two fluids. A simple but rough method of getting this is to strike an average between the temperature difference at one end of the apparatus and that at the other. The trouble with this method is that the true "mean temperature difference" often differs considerably from the figure that is obtained by taking a simple average in the manner described.

By the use of the accompanying diagram it is just as easy to obtain the theoretically correct value of the "mean temperature difference." This diagram can be used with either counterflow or parallel-flow apparatus. It is also applicable where one fluid remains at constant temperature while the other is heated or cooled.

The dotted line and arrows illustrate the method of solution for the case where the greatest temperature difference is 158 deg. and the least temperature difference 70 deg. Here the mean temperature difference is found to be 108 deg., whereas a simple average of the two extremes would give (158 + 70) ÷ 2 = 114 degrees.

As another example assume that the temperature difference between the fluids is 90 deg. at one end of the apparatus and 80 at the other. For this case the true mean temperature difference is found (by the diagram) to be 86 deg. This is practically the same as 85, the arithmetical average of 80 and 90.

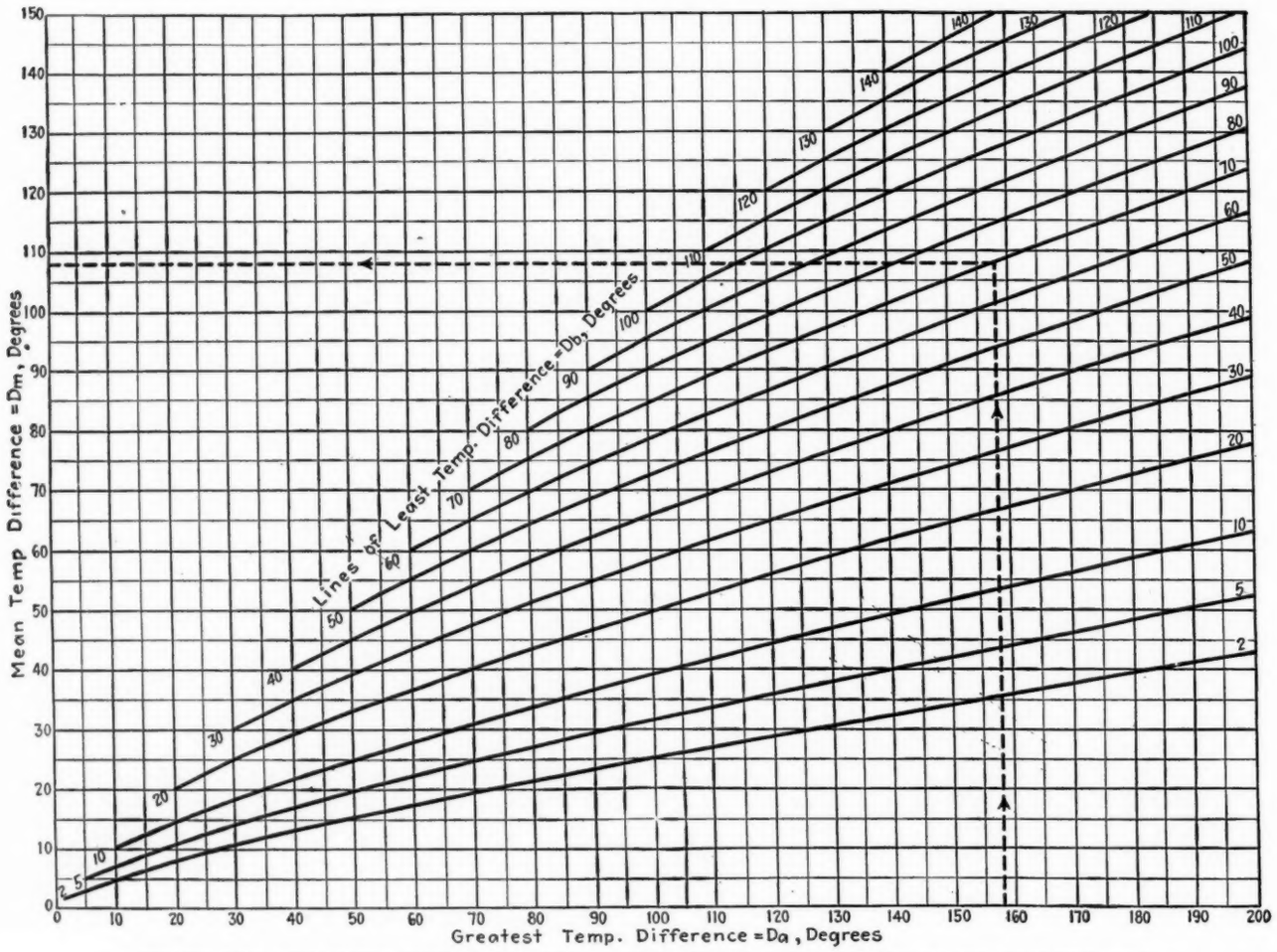


CHART FOR OBTAINING THE TRUE MEAN TEMPERATURE DIFFERENCE IN OIL COOLERS, ETC.

To use the chart, it is necessary to know the entering and leaving temperature of both liquids. The first step is to get the difference in temperature between the liquids at one end of the apparatus. The corresponding difference for the other end is then obtained. Then enter the chart at the bottom with the greater difference. Rise vertically to the inclined line marked with the smaller difference. Then move horizontally to the left-hand scale, which will give the "mean temperature difference."

This chart is based on the following simplified form of the Grashof formula:

$$D_m = \frac{D_a - D_b}{Log_e \frac{D_a}{D_b}}$$

in which D_m = mean temperature difference; D_a = greatest difference in temperature between liquids; D_b = least difference in temperature between liquids; Log_e = Napierian or hyperbolic logarithm.

EDITORIALS

Utilizing Waste Heat of Oil Engines

ONE of the factors that have prevented a more general adoption of the oil engine is the necessity of having a supply of steam or hot water in the factory. This is especially true in the Northern States, where the buildings must be heated for six months a year, and also in the textile and other industries, where steam is required in the various processes. The result has been the practical exclusion of the oil engine in many factories when a power-plant is being considered. The superior efficiency of the oil engine has not been able to overcome the advantage of the steam plant in such cases.

Engineers would do well to study the merits of the oil engine when combined with an exhaust-heat boiler. Operation of the combination indicates that at low loads (less than two-fifths full load) the recovery is zero. At loads where the mean effective pressure in the engine is over thirty pounds, the recovery is in direct ratio to the increase in mean effective pressure above thirty pounds. At full load the recovery can be as high as four pounds of steam per engine horsepower. In a plant carrying a five hundred horsepower engine load, the recovery would be two thousand pounds of steam an hour. If the evaporation in an ordinary boiler plant is assumed to be seven pounds of water per pound of coal, the exhaust boiler would save about three hundred pounds of coal an hour or one and one-half tons a day. At the prevailing prices of coal and boilers the cost of the boiler would be recovered in less than a year.

The objection may be made that a plant having five hundred horsepower load will require over two thousand pounds of steam for processing. This may be true in exceptional cases, but the hot water or steam demand is small in most industrial plants. For steam- or hot-water heating it would seem that the exhaust is sufficient for any well-built factory.

Welded Boilers

A MENACE to public safety, which is assuming serious magnitude by reason of the large number that are coming into use, is offered by the miniature boilers used to furnish steam for clothes pressing and similar small uses. Their diminutive size and relative unimportance has exempted them from official supervision; they are usually installed by the local plumber or steamfitter and gas-fired under the charge of the user.

It is possible, however, even under the condition of ordinary operation, to accumulate a dangerous amount of energy in a vessel of this kind. At one hundred pounds pressure each cubic foot of the contained water will, upon being liberated to the atmosphere, set free 471,101 foot-pounds of energy, which, if its release occurs in one-tenth of a second, will be equivalent to the impressment of 8,565 horsepower upon the surroundings for that length of time.

Such a boiler exploded recently in a pressing club in the basement of a building in Thomson, Georgia. It was a vertical-flue boiler, 18 inches in diameter, 36 inches long, with a 16-inch furnace 14 inches high, having a 6-inch flue extending to the top head. The shell was of ⅛-inch galvanized iron and the furnace of $\frac{3}{32}$-inch steel. All joints were welded. The boiler was bought from a mail-order house. It was projected through three floors of the building which housed the Southern Bell Telephone Company's exchange and equipment, seriously injured several people and went fifty feet into the air, landing on the roof. It gave way at the weld which joined the O G at the bottom of the surface to the shell.

It is the possibility of this kind of thing that has justified the conservative attitude of the Boiler Code Committee and of the governmental inspection bodies with regard to the use of welding in boiler and pressure-vessel construction. Much excellent welding work is being done. There are many applications where its use is particularly advantageous. Properly done, it is reasonably safe for many uses even under pressure; but as yet no practical means for determining whether a joint is properly made has been developed, short of a test to destruction.

A Valuable Contribution to Steam-Turbine Engineering

RESULTS of tests made on a sixty-thousand-kilowatt turbine in the Seventy-fourth Street plant of the Interborough Rapid Transit Company, New York City, are published in this issue. These tests are of special interest since they were made on one of the largest machines in operation in this country. Their accuracy equals, if indeed it does not surpass, that of any other tests made on large machines, and they were made under substantially service conditions, the turbine being allowed to take the load swing. The most difficult problem in testing on large turbines is that of accurately weighing the condensate. When it is considered that in two of these tests over eight hundred thousand pounds of condensate per hour had to be handled, the difficulty of obtaining an accurate measurement is at once apparent. In this plant there were available two large storage tanks of three hundred thousand-pounds capacity, which, before making the tests, were carefully calibrated by filling with water weighed on platform scales. In this way it was possible to get the actual weight of steam to within a fraction of one per cent. Since great care was exercised to obtain correct measurements all through the tests, they are undoubtedly highly accurate and within the percentage of error claimed—five-tenths of one per cent.

The best water rate obtained for the whole unit was about eleven pounds per kilowatt-hour. This figure appears to be higher than that of some machines recently placed in operation. However, the steam conditions in the Interborough plant are considerably below those in some more modern station. If the results

were to be considered on the basis of steam at two hundred and sixty-five pounds absolute and two hundred and twenty-five degrees superheat, worked to the same final condition as obtained in the tests, the water rate would be close to ten pounds per kilowatt-hour.

This test is the third that the Interborough Rapid Transit Company's engineers have conducted and presented to the engineering profession. The results of the previous tests, which were made on thirty thousand-kilowatt units, were published in *Power*, May 23, 1916 and May 24, 1921. It is regretted that more complete tests have not been made on large turbine units, and it is even more regrettable that in some cases there is a tendency to prevent the results of tests becoming public. Such tests are expensive both in money and in engineering effort, therefore the highest commendation is due not only to the Interborough Company and its engineers, but also to the manufacturers of the equipment for making the tests and giving publicity to the results.

Why Not Provide Proper Protection?

WITH a single generator supplying a load of lights and motors, fuses or an overload type of circuit breaker, when properly installed and maintained, will in general give the necessary protection to the equipment. As systems increase in size, so as to involve not only a number of generators operating in parallel, but power stations and substations all tied together through a network of feeders, the devices that give sufficient protection to a single generator prove inadequate. An alternator properly designed can be connected to its load without any protection, but, when this same machine is connected in parallel with other machines, it becomes necessary, as has been proved by a number of disastrous burnouts, to provide protection that will disconnect the machines from the circuit in case of internal trouble. In this event the machines are capable of withstanding an external short-circuit, but if a failure occurs in the windings of one machine, not only the machine in trouble, but all the rest of the generators on the system supply power into the fault. Experience has shown that before the operator can get the faulty machine off the system both windings and core will be seriously damaged, in many cases necessitating complete rebuilding of the stator. When proper protection is provided, the damage done is generally slight.

Where a direct-current generator station is tied into an alternating-current generator station through rotary converters or motor-generator sets, there is always danger of the direct-current generators motorizing the converters and causing them to race, especially if the machines are of the compound type. If the load is light on the alternating-current system, the converters will run the frequency up and motorize the alternators, which may reach a speed sufficient to wreck the prime movers. Here the overspeed trip on the prime mover cannot prevent racing; all that it can do is to close the emergency throttle and prevent the engine room from being filled with steam in case of engine or turbine failure. Additional protection must be put into the electrical system in the form of reverse-power and reverse-current relays, to prevent reverse flow of power in the system.

Conditions that arise in electrical power systems that require special protection could be enumerated almost indefinitely, but the fact remains that the difference in cost between the cheapest protective devices and the very best is only a small fraction of one per cent of the total cost of the system protected. In the light of these facts why is it that so many accidents are allowed to occur in power stations—accidents that cost thousands of dollars in damaged equipment and in many cases much more in lost production—which might have been prevented by investing a small amount in protection for the equipment? Is it not time that those responsible for this condition gave serious thought to the matter?

Fuel Oil and Conservation

IN VIEW of the fact that the world's known oil resources can last only a few decades at the present rate of consumption, while there is coal in sight for hundreds of years, it might seem almost criminal to burn oil under boilers. It can hardly be denied that this invaluable resource is being recklessly and lavishly used. At the same time the blame for this—if blame is permitted in matters of cold business—cannot be laid at the door of the man who uses oil for fuel unless he burns it in the form of crude oil.

Fuel oil, as ordinarily used, is a residue from which the gasoline and other valuable constituents have been removed. The amount of fuel oil produced is, under present conditions, regulated largely by the gasoline demand. In fact it may be regarded as a byproduct of gasoline manufacture, since the crude oil is taken from the ground to meet the enormous demand for gasoline. Storage capacity is necessarily limited, so the average price of the residue must automatically seek such a level that industry will absorb all that is produced. Conservation of petroleum resources must come, if at all, by using less gasoline or by recovering a larger percentage of gasoline from the crude oil.

This discussion touches on some facts that are brought out more completely by E. J. Billings in his article, "Why Fuel Oil Must Continue To Compete with Coal," in this issue. However, the relation of fuel oil to conservation is shown only "between the lines" of Mr. Billings' paper. In the future as in the past each plant operator will decide on coal or fuel oil solely on the basis of relative price and suitability to his conditions. At the same time, if fuel oil happens to win out, he may use it with clear conscience as long as gasoline demand determines oil production.

The use of pulverized coal should be surrounded with the proper safeguards. In a compact mass it may be handled with perfect safety; diffused in the atmosphere, it may be as much of a hazard as oil. Word is just received of an explosion in a coal-pulverizing mill in the steam plant of the Puget Sound Light and Power Company, Seattle, which severely burned two workmen and tore apart the corrugated iron covering of the building. The Oil Safety Commission held a hearing upon the hazard from its use a year or more ago with the view of adopting suitable regulations, but we have not learned of their formulation.

Any readers of *Power* who ever have occasion to figure the heat transfer in oil coolers or similar apparatus should clip out, or make note of, H. L. Doolittle's diagram for determining the true mean temperature difference. This diagram, together with instructions for using it, can be found on page 428 of this issue.

PRACTICAL IDEAS from PRACTICAL MEN

Adjusting Crankpin Boxes

Many stationary engines are equipped with connecting rods of the marine type, as shown in Fig. 1. The crankpin boxes, which are bolted to these rods, while of simple design, are more difficult to adjust accurately than are boxes of either the old-fashioned gib-and-key type, shown in Fig. 2, or the modern draw-wedge type, shown in Fig. 3.

With the gib-and-key brasses all the engineer had to do, when tightening up the adjustment, was to slack off the setscrew, drive the key until the brasses fairly clamped the pin and then drive the key back a wee bit and tighten the setscrew. But just how strong to make that wee bit of withdrawal was something the engineer generally had to learn from experience for the particular set of brasses he might be working with. Usually, however, the taper of the key was the determining factor. If he drove the key back just enough to enable him to slip the brasses back and forth between the collars of the pin—presuming, of course, that the brasses had about $\frac{1}{32}$ or $\frac{1}{16}$ in. end play, which they ought to have—he was generally safe.

With the draw-wedge type of connecting rod it usually suffices to slack off the bottom wedge bolt and pull up on the top bolt until the brasses are snug on the pin, and then to slack off the top bolt one-sixth of a turn and tighten up with the bottom bolt. This means that the engineer turns the top bolt back until one certain facet of the hexagon head has displaced the facet next to it in a counterclockwise direction. In other words, he slacks off "one flat of the bolt head."

This will generally suffice to give the brasses enough clearance to keep them cool, and not so much as to cause a pound. Sometimes, owing to some slight structural defects of the bolts, wedge or brasses, slacking off "one flat" may prove inadequate. In such cases the engineer has simply to learn experimentally the proper adjustment.

Crankpin boxes of the marine type on stationary engines are usually adjusted by means of thin liners clamped between the two halves of the box. The thickness of one of these liners gages the least amount the box may be taken up or eased off. But the thickness is usually so small that when the box becomes loose enough to produce a pound as the engine passes the centers, removal of one liner above and one below the pin will bring it back to a noiseless adjustment and still leave a safe clearance.

Sometimes the only safe procedure in lining up this type of box is to disconnect the crosshead end of the rod and swing the rod on the crankpin to test the adjustment. This method is objectionable, however, inasmuch as it leaves the engineer in the dark as to the exact amount of clearance between the pin and the box. Such adjustment is largely a matter of guesswork.

Another method, and one that is often resorted to, is to tighten up the nuts on the clamping bolts until the two halves of the box hug the pin and then to slack off a certain amount. The amount of clearance is thus gaged according to the pitch of the thread on the bolts. If the hexagon nuts are turned back one facet, then the clearance will equal exactly one-sixth of the pitch of the thread.

The objection to this method is that it is dangerous, because when the nuts are locked after being slacked off, the bolts themselves still remain in a slackened condition. The bolts are thus subjected to shocks as the

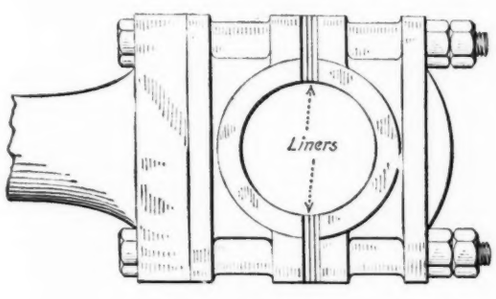


FIG. 1. MARINE TYPE OF CONNECTING ROD

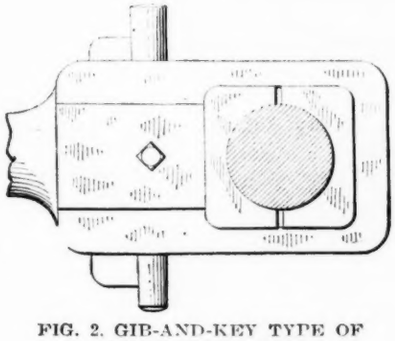


FIG. 2. GIB-AND-KEY TYPE OF CONNECTING ROD

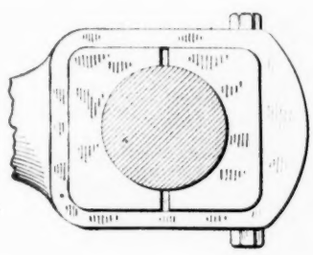


FIG. 3. DRAW-WEDGE TYPE OF CONNECTING ROD

engine passes the outer dead center, which tends to crystallize and break them.

The clearance of the crankpin boxes of the marine type may be gaged by inserting lead wires between the box and pin and then pulling the two halves of the box solidly together. The thickness of the flattened wires will then indicate the amount of clearance. If the clearance is thus found to be too great, liners may be taken out or thinner liners may be substituted.

To do this job properly, a micrometer caliper should be used in measuring the thickness of the flattened leads, since the clearance should be determined to thousandths of an inch per inch of pin diameter.

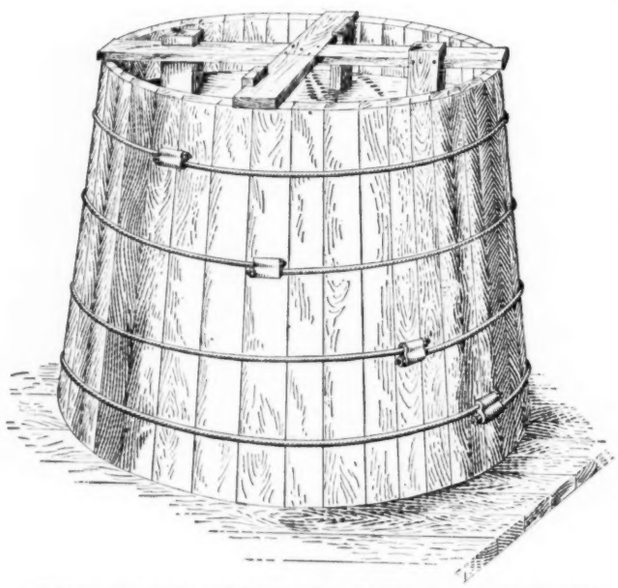
Another method of adjusting the marine type of crankpin boxes is to line up the boxes, while removed from the pin, in accordance with the indications of a pair of inside calipers set to the diameter of the pin plus the amount of clearance required. This is the method followed in fitting the main-rod brasses of locomotives.

The main crankpin boxes on locomotives are usually fitted brass-to-brass, without any liners intervening. No provision is made for keying up. When the brasses are worn to the pounding stage, they must be removed from the pin and filed to a proper fit. This procedure is adopted principally to forestall any chance of an engineer pulling the brasses up too tight. A. J. DIXON.

St. Louis, Mo.

Preventing Water Tank from Bursting

To insure a temporary supply of water at a coal mine that had suspended operations for the winter months, a round wooden tank 20 x 18 ft. high was pumped full of water. To prevent bursting of the tank by freezing, two planks were placed at right angles across the top,



THESE TIMBERS PREVENTED TANK FROM BURSTING

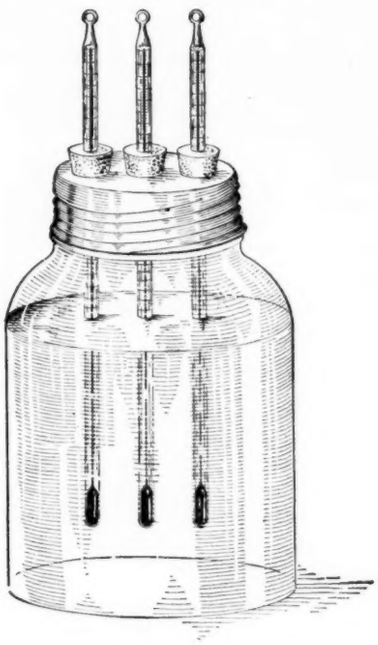
and suspended vertically to these were several 2 x 6, 2 x 4 and 4 x 4-in. soft-pine timbers reaching to the bottom of the tank.

Although this tank froze solid it was uninjured as the soft-pine timbers took up the contractional and expansional strains. J. L. BALL.

Amsterdam, Ohio.

How to Check Thermometer Readings

Some time ago, owing to the widely varying results obtained, the testing thermometers we were using caused us to question their accuracy. Following the rule that thermometers when immersed in a liquid of



ACCURATE THERMOMETER IMMERSED WITH TWO TO BE CHECKED

uniform temperature will indicate their accuracy when compared with a calibrated instrument, a quart-sized fruit jar was obtained and holes cut into the metal cap to hold three ¾-in. corks. Each cork had a hole bored through it small enough to grip the thermometer tightly.

By filling the jar with hot water and making a record of the thermometer readings at ten-minute intervals and taking the average difference, over as large a range as possible, the percentage of error was found and a coefficient of correction was easily calculated and applied to the thermometers that did not register within allowable limits. J. H. SCHALEK.

Pittsburgh, Pa.

Blowoff Valves on Shipboard

In marine-boiler practice the bottom blowoff line is common to all boilers. It is also connected to one or two pumps which circulate the water when the boiler is being fired from a cold start. The blowoff pipe discharges through the side of the ship, where it is connected by a bronze plug cock riveted to the ship's side. This cock is always opened before the blowoff valve and is closed after the blowoff valve.

It is seldom that trouble is experienced because of the valves or cock leaking. In taking down eleven such lines in the last few weeks, but one cock was found to be leaking, and that was plainly the result of abuse. Judging from the methods used in connecting such fittings to stationary boilers, it is my opinion that they are subject to severe expansion and contracting stresses, which distort the cock and valve bodies and result in leaks that no amount of repair can stop for long.

Portsmouth, Va. C. F. DASSEY.

Why Did Water Pass from One Boiler to Another?

A plan view of a pair of return-tubular heating boilers working under 35 lb. pressure is shown in Fig. 1. The outlets *A* and *B* are 4 in. in diameter, and the main pipe *C* is 5 in. Fig. 2 is an elevation of the same, showing the distance of 27 in. from the upper tubes to the

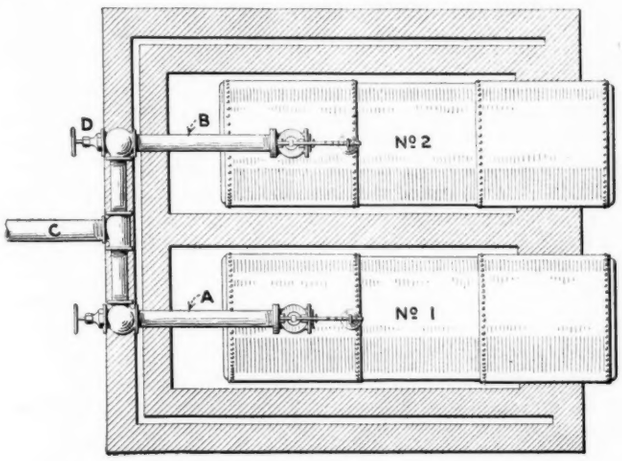


FIG. 1. PLAN OF THE TWO BOILER SETTINGS

shell. A tee is bolted to the steam nozzle, with a lever safety valve set to blow at 40 pounds.

On a certain occasion the high-water alarm whistle on boiler No. 1 began to blow vigorously. The engineer, observing that the water level was high in the glass, went to the rear to open the blowoff valve on that boiler. While he was doing this, the fireman told him

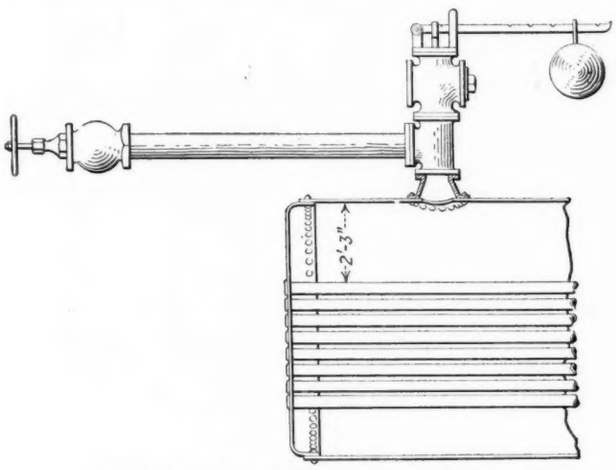


FIG. 2. ELEVATION OF THE BOILERS

that the water level in No. 2 boiler was falling fast. Hastening to the front (after closing the blowoff on No. 1), he saw that the glass of No. 2 boiler indicated about 4 in. of water, but in less than 30 seconds it disappeared, causing the low-water alarm to blow. The fireman quickly covered the fire with wet coal. The assistant engineer closed the angle valve *D* on No. 2 boiler and concentrated into No. 2 the feed usually delivered to several other boilers. In a few minutes the water appeared in the glass, and when it indicated 3 in., the alarm ceased to blow. Soon afterward the glass showed 6 in. of water. What caused the water to disappear from No. 2 boiler and appear in No. 1? Why did it cease flowing when the 4-in. angle valve *D* was closed?

In order to show what did not cause the trouble, it is necessary to study the details of Fig. 3, which shows a section of the main feed pipe *E* and the branch line to boiler No. 1. The branch line to No. 2 boiler is the same. The feed valve *F* is opened wide or closed tight, according to requirements. Ninety pounds pressure is carried on the feed line for feeding other boilers in the plant. The globe valve *G* is fitted with a throttle nut *H* to obstruct the flow of water under this wide difference of pressure. An angle check valve is located at *I*; the gate valve *J* is for emergency use. As soon as the water level rose in boiler No. 1 causing the high water alarm to blow, the fireman closed the valve *F*. If the valve *G* had failed to perform the duty for which it was installed, water rushing in from the feed pipe *E* would have raised the level in boiler No. 1, but that would not account for the sudden fall in No. 2 boiler as such a large quantity of water passed from one boiler to the other in less than two minutes, while the valve *F* was closed.

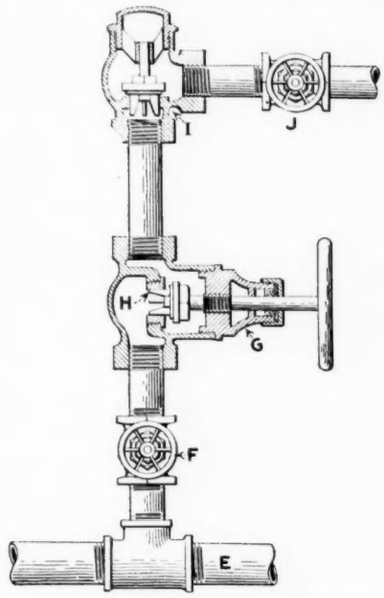


FIG. 3. VALVES OF FEED-WATER PIPE

Both boilers were operated under about ⅜ in. of forced draft, but at this time the draft was shut off from No. 1 boiler with a brisk fire under No. 2. At the same time the demand for steam through the pipe *C*, Fig. 1, was unusually heavy, causing a slight reduction of pressure in No. 1 boiler while it was increased in No. 2. Would the rush of steam from one boiler to the other carry enough water with it to account for the action described?

W. H. WAKEMAN.

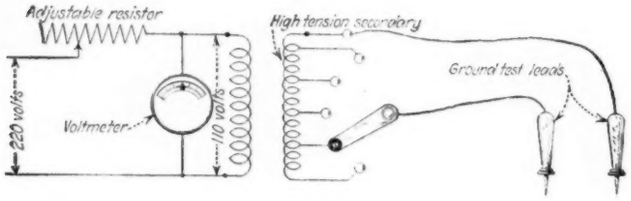
New Haven, Conn.

Improved Type of Ground-Test Box

A standard 110-volt high-tension transformer was used for testing the insulation of meters. This transformer was provided with a circuit breaker and indicating lamp in the primary in the regular manner, so that when the secondary leads were touched to the winding and base of an instrument having defective insulation, the resulting rush of current would throw out the breaker, thus indicating a ground.

A bad fault with this apparatus was that whenever a ground occurred the resulting current was so heavy that it often damaged the insulation beyond repair. This necessitated an entire reinsulation where perhaps

the ground could easily have been repaired, had it not been burnt so badly. In order to avoid this, the 110-volt winding was placed in series with an adjustable resistor, and this resistance adjusted so that when the combination was put across 220 volts, there would be 110 volts on the transformer primary, the same as before. The diagram of connections is shown in the figure, which also shows a voltmeter connected across



PRIMARY OF TESTING TRANSFORMER CONNECTED IN SERIES WITH ADJUSTABLE RESISTANCE TO LIMIT SECONDARY CURRENT

the primary of the transformer in order to maintain the exact voltage.

The difference in operation was that now when a ground occurred, the primary current had to pass through the adjustable resistor. The result was that the voltage during the breakdown would drop to almost zero across the transformer primary, while it would rise across the resistor to almost full line voltage. The current drawn from the line could be only about double the normal operating current in the worst case of a dead ground, instead of being of a magnitude of a short-circuit current.

It will be noticed that with the secondary leads on open circuit, as would be the case with perfect insulation, the voltage would be at its normal rating. This would impose a strain on the meter's insulation equal to that of the transformer, with a circuit breaker in the primary but without the adjustable resistance. The difference is, however, that the rush of current during a breakdown is limited with the adjustable resistor, thus preventing serious damage to the insulation, and at the same time showing readily the location of the ground.

VICTOR H. TODD.

Summit, N. J.

Changing From Single to Three-Phase Improves Voltage Regulation

On taking charge of this plant the only equipment we had was a 15-kva. three-phase alternator of the self-contained type; that is, the exciter and alternator are contained in the one machine. This machine had three slip rings, but had always been operated single-phase, and if anyone connected in a flatiron or washing machine, the voltage was liable to drop to zero. Then, to get it back into service it was necessary to pull out the main switch, build up the voltage and throw the switch in again. When the load was thrown on suddenly, the belt would slip irrespective of how tight it was, and the static electricity was so strong that one would get shocked when within twelve inches of the belt.

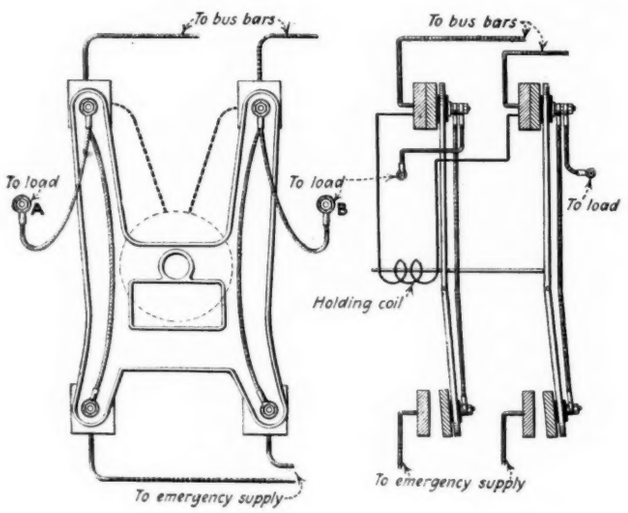
The machine was changed over to three-phase by fitting in the third brush and a third wire was connected in on the system, which stopped the trouble with the voltage. The belt was thoroughly treated with dressing and the generator slacked off until there was a six-inch sag in the belt. I drove an iron pipe in the ground three feet deep on each side of the belt, 18 in. from the generator, so that they would clear the belt 1½ in. on each side. Since this was done, the static has never been noticed. I have also taken the static from two other generator belts by the same method.

Peetz, Col. W. L. HALDEN, Supt. Water and Light.

Automatic Switch To Connect to Emergency Power Supply

In some plants it is essential that the power supply to emergency lights, elevators and even some processes be not interrupted. In one plant that had its own power station, emergency service was supplied from a street circuit, and it was arranged so that by a double-pole double-throw switch the load could be thrown from the switchboard busbars to the street circuit in case of failure of the power station. This arrangement, even if the engineer was right on the job, required considerable time before the change over could be made, so it was decided to try and arrange to make this function automatic if it could be done at reasonable cost.

A double-pole double-throw contactor was obtained from a second-hand electrical shop. The contactor was originally equipped with copper-to-carbon contacts, therefore to increase their current-carrying capacity it was decided to make all contacts copper-to-copper. Both ends of the contactor arms were equipped alike, and the movable contacts on each side were connected together and a lead brought from each pair to a stationary terminal, *A* and *B*, to which the load circuit was connected, as indicated in the figure. The generator was connected



FRONT VIEW AND DIAGRAM OF DOUBLE-POLE CONTACTOR

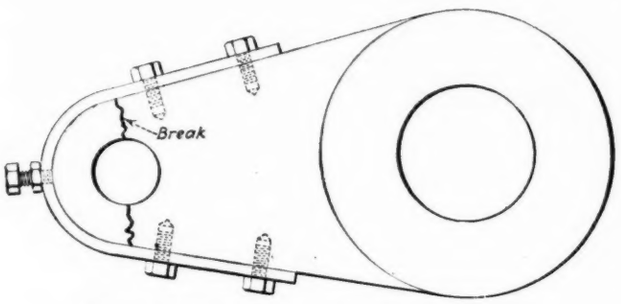
to the top contacts and the street service to the bottom. The holding coil was connected to the top contacts, as indicated, so that when there is voltage on the busbars the contactor will remain closed to this position. However, when for any reason the voltage fails on the busbars, the contactor immediately falls to the emergency source. After this switch had been installed, it was found that the change from one source to the other was made so quickly that an interruption to the service could hardly be noticed.

New York City. W. A. HARRIS.

Bell-Crank Repair Quickly Made

While I was in charge of the maintenance department of a coal-mine plant, a bell crank of the valve gear on a Corliss engine broke through the pin-hole as shown.

There being no spare bell crank to replace the broken one and as the failure had occurred at a time when every minute counted, it was important to make a repair quickly, and after a few moments thought, the method described herein was adopted.



SHOWS HOW URGENT REPAIR WAS MADE

A piece of ½-in. x 1¼-in. mild-steel bar was bent to fit the broken arm and then drilled for the capscrews and drilled and tapped for the setscrew. The strap was fitted over the arm and the holes scribed and then drilled with an electric hand drill and tapped for the capscrews. The broken piece was placed in position, the strap applied and tightened in place. The setscrew was then screwed down and the locknut tightened. This repair was made in less than an hour without removing the bell crank from the engine and proved to be permanent, as it was still in operation two years later.

Oak Grove, Ala. F. C. SINBACK.

Locating Cause of Induction Motor Hunting

Recently, one of our motors, a 200-hp. 2,300-volt three-phase wound-rotor type, direct coupled to a centrifugal pump, developed a bad case of hunting after being started in the morning. Starting was accomplished in the usual way, applying full voltage to the motor's primary winding and cutting out resistance in the rotor circuit.

The motor seemed to reach full speed under the usual 75 per cent full load. As the load was being increased, the primary current suddenly jumped to 125 per cent of normal, and the voltmeter and ammeter pointers began to swing violently. At the same time it was noticed that the motor was hunting badly. But for the time limit relay, the running switch would have tripped out. The operator immediately shut down the motor and made an examination, particularly at the brushes and rings. Also the junction of the rings and coil leads were examined. The starting resistance contacts were also gone over, but everything seemed normal. Upon starting again, the motor ran as usual with no indication of hunting.

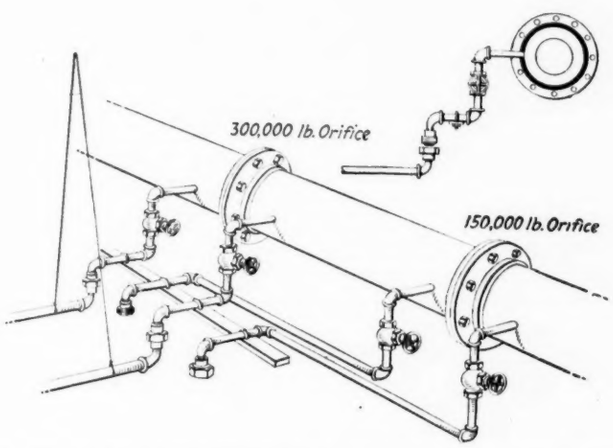
Thinking that perhaps starting the motor had produced oscillations in the transmission system, which affect a synchronous unit, nothing further was done. A few mornings later the same thing happened again, only worse. The operator tripped out the switch and upon starting again, conditions were normal. Two days later, when starting, the motor fired badly in the rotor winding and tripped the switch. A point on the rotor winding was found where current had arced from one coil to another. By following this phase back and forth through the winding and carefully examining all soldered joints, three were found that looked as if they might be loose. The paint was scraped off and the coils were found to be loose in the connectors. These were soldered up, and we have had no more trouble.

Pittsburgh, Pa. M. A. ANDERSON.

Piping for Water Meter Using Two Orifices

We have a water meter on a 6-in. boiler feed line which is arranged to be used on either of two orifices, depending on the load. Until recently the orifices have been permanently piped so that by opening two valves and closing two valves the meter could be changed from one orifice to the other. This annoyance, however handy, has its drawbacks. A leaky valve on the orifice supposed to be shut off will make the meter read wrong and it is not possible to detect the leak without taking down the piping.

To overcome this condition the piping was arranged as shown in the sketch. Each pipe is run separately to a common point and ends with one-half of a metal to metal union. The pipes are grouped so that the two high-pressure pipes come out together and the two low-pressure pipes together, with the half unions evenly spaced about 4 in. apart and in line. The pipes were also fastened with U-bolts to a ¼ x ¾-in. strap, which makes a substantial construction.



METHOD OF CONNECTING TWO ORIFICES TO ONE METER

The other halves of the unions are on the pipes leading to the meter. The unions are placed in the vertical pipes. This is thought advisable so that as little water as possible would be lost out of the pipe while changing from one orifice to another. While the unions are disconnected the long pipes leading to the meter are supported by a wire from a point above. In order to save unions and to avoid confusion in making connections the high-pressure pipes end with the male half of two unions and the pipe to the meter carries the female, while the low-pressure pipes end in female

halves and the pipe to the meter has the male half. It will be seen that three unions are necessary in which the halves are interchangeable.

It is but little trouble to change from one orifice to the other, and, of course, there is no chance of one orifice interfering with the other.

Albany, N. Y. C. N. HUTCHINSON.

Correcting Trouble on New Automatic Voltage Regulator

The automatic voltage regulator for alternating-current generators is usually somewhat puzzling to power-house men, especially if it is new to them. Recently, a regulator was added to an industrial power house to regulate the voltage of two 1,500-kw. generators, the regulator controlling one of two 75-kw. exciters. It was found desirable to have a regulator on account of the fluctuating nature of the load and to prevent disturbance on a tie line connecting the station with a larger industrial power plant.

The behavior of the regulator was somewhat erratic. For a time it would function perfectly and then apparently would suddenly go wrong and the generator would drop its load and the tie-line switch between stations would kick out before the generator could be cleared from the line. It was found that this condition usually occurred when the generator was running near full load, or when the load was shifted from one generator to the other preparatory to shutting down one of the generators. A careful check of the connections and adjustments of the regulator indicated that the trouble was not in the regulator itself. As the characteristics of the generators were standard, possibility of trouble from that source was dismissed.

Attention was then centered on the exciters, which were furnished originally with overcompounded fields and whose maximum voltage was 150 at full load. In order to adapt the exciters to the regulator, it had previously been necessary to change the compounding shunt of the machines so as to give a slightly drooping characteristic to the voltage curve of the exciters. This was necessary since an overcompounded exciter will not allow a regulator to function to properly control the voltage of the system. This change cut down the maximum voltage of the exciter to 130. It was necessary to leave some of the main field rheostat of the alternators cut in the field circuit in order to regulate the distribution of wattless current between generators, consequently it will be seen that some of the 130 volts remaining would be lost in this rheostat. By cutting the regulator out of circuit for a few days and restoring the overcompounding of the exciter, it was found that a maximum of 140 volts was required with the main-generator field rheostat set in the position determined for proper operation in connection with the regulator.

As the exciters were of the same make as the automatic regulator, the data secured from the foregoing tests were referred to the manufacturer to secure a remedy for the trouble, as apparently nothing further could be done by the operators. The manufacturers furnished new polepieces (Fig. 2) for each exciter to replace those which were originally installed and which, when the machines were dismantled, were found to have a reduced cross-section at one point, as in Fig. 1. The new polepieces therefore allowed a lower reluctance in the magnetic circuit, giving a greater amount of magnetic flux with the same shunt winding. The exciters, after being fitted with the new polepieces, gave about 155 volts at no load and about 145 volts at full load when operating as a shunt machine. The regulator and the various rheostats were adjusted with the new voltage characteristics of the exciters and have given satisfactory regulation and no trouble has been experienced since the higher voltage has been available from the exciters.

The cause of the generator dropping its load under the conditions described, was evidently due to some sudden increase of load either from starting a large motor or a decrease in voltage of the main generating station. This increase of load, coming on when practically the maximum field current available existed in the generator field, caused a sufficient demagnetization of the generator field to lower the voltage of the motor driving the exciter, which in turn, by a reduction in

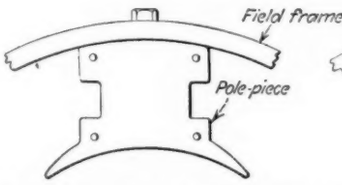


FIG. 1. SHAPE OF ORIGINAL POLEPIECES USED IN EXCITER

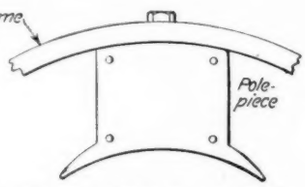


FIG. 2. SHAPE OF NEW POLEPIECES USED IN EXCITER

speed, further lowered the exciter voltage. This condition acting cumulatively would quickly drop the station voltage to zero after the field of the generator was reduced to an unstable point with respect to its load. When the exciter has a sufficient surplus of voltage to increase the alternator's field current, any sudden demagnetization of the generator field, due to increase of load, is counteracted and equilibrium is obtained under almost any condition whether operating as an isolated station or tied in with other stations. To illustrate this effect with the voltage regulator cut out, a 200-hp. motor driving an air compressor was started, the generator carrying 1,200 kw. on an isolated system. Without changing the field rheostat setting, the voltage dropped from 2,200 to 1,400. When the voltage reached 1,400, if the exciter voltage was not raised, that of the generator dropped from the 1,400 point to zero. The generator speed variation was less than 1 per cent during the tests, therefore it could not have been in any way responsible for the drop in voltage.

J. E. HOUSLEY, Elec. Engr.,
East St. Louis, Ill. Aluminum Ore Co.

Most Evaporators Use Live Steam

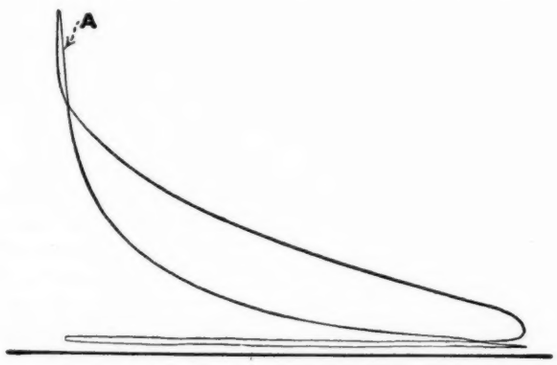
Power's attention has been called to a statement in the article entitled "Evaporators—What They Are and How They Operate" in the Feb. 21 issue. On page 292 the following sentence occurs: "However, power-plant evaporators are almost invariably operated by steam and usually (in stationary plants) by exhaust steam."

It appears that in the portion which reads "and usually (in stationary plants) by exhaust steam" the word "exhaust" should have been "live," since the majority of these evaporators are operated by live steam, rather than by exhaust steam. Incidentally, it was not the purpose of this article to discuss commercial applications, but merely to show general principles.

A Peculiar Diesel-Engine Diagram

Referring to Mr. Jones' Peculiar Diesel Engine Indicator Card in *Power* of Jan. 10, I would offer some explanations very different from those of Mr. Smith in the issue of Feb. 14.

There are two possible explanations for the fact that the maximum pressure is reached before the minimum volume, or the end of the stroke, as shown by the diagram which is here reproduced. A drop in pressure might result from a leaky valve, although not very prob-



PECULIAR DIESEL INDICATOR DIAGRAM

able in this instance on account of the magnitude and abruptness of the drop on the diagram. Mr. Jones said that he had attached the indicator rigging to the shaft of the engine. The drop in pressure before dead center would be only apparent and not real if the rigging was fastened out of alignment with the center line of the crank. In this event the engine would be on dead center slightly before the indicator drum reached the end of its travel.

The fact that the pressure on expansion falls below the compression pressure may be due to loss of heat through the cylinder walls and will always appear on a Diesel diagram when fuel injection occurs after dead center. Mr. Jones said that his fuel valve had been set to open four degrees before dead center, but I suspect that it was opening afterward.

A combination of late fuel-valve opening and an indicator rigging slightly out of time with the piston will account for the character of the loop and also for the fact that there is no well-defined combustion line.

M. A. DURLAND, Asst. Prof. Mach. Des.
Kansas State Agricultural College.
Manhattan, Kan.

Do Operators Really Want Better Firebrick?

Your editorial in the Jan. 24 issue, entitled "Does Firebrick Limit Combustion Progress?" was of considerable interest to manufacturers of refractories. It brings out very clearly that the manufacturers of firebrick are no longer willing to take the blame for the refractory troubles encountered by the boiler manufacturers and users. Refractories manufacturers have long been awake to the fact that progress in boiler design and operation would be limited unless the new conditions imposed upon refractories were met. Unquestionably, the consumers of refractories have only themselves to blame because they have not taken advantage of the products offered them.

As long as sixteen years ago one of the large manufacturers of firebrick established a research laboratory and began to develop a super-refractory for high-temperature work. A commercial product was developed that withstood higher temperatures than any refractory on the market at that time. However, its cost was naturally higher than ordinary firebrick, and it met with little success.

About thirteen years ago another refractories company developed a product which withstood higher temperatures than any of the best brands of No. 1 firebrick. While the composition and physical properties of this product were ideal for use in boiler settings, the manufacturer found it impossible to interest the power-plant operator and naturally sought other markets for his product. A number of the large refractories manufacturers have been interested in this subject from time to time, but have become discouraged when they found that the power operator lost interest when he found that he could not purchase a refractory that would answer his requirements at as low a price as he could obtain No. 1 firebrick.

This question of prices seems to have been the crux of the whole situation. About five years ago the writer had a conference with the engineers and officials of one of the largest boiler manufacturers in the country on the subject of producing a super-refractory that would eliminate the difficulties they were encountering at that time. The writer made the proposition that his company would agree to do the necessary research and development work to produce a super-refractory if they would agree to purchase the product for their installations. When these men were told that brick having the necessary qualities would cost approximately $150 per thousand, they immediately replied that such a price was out of the question and that unless a product could

be made to sell for the price of ordinary No. 1 firebrick they would not be interested.

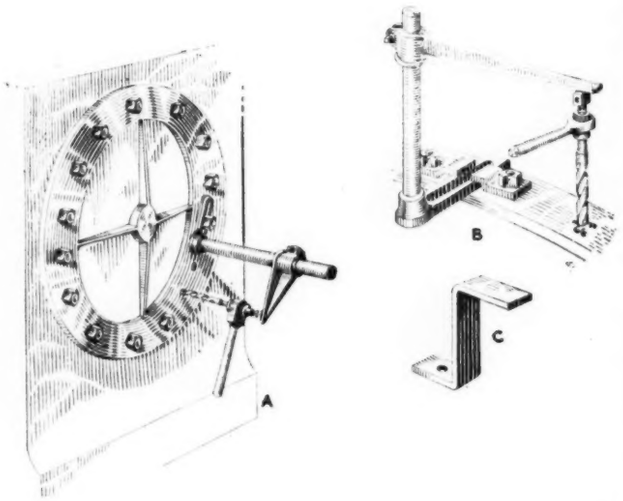
This is a splendid illustration of the attitude of the consumers up to within the last year or year and a half. During the last year there has been a decided "change of heart" in regard to the price question, and the consumer has come to the realization that he can afford to forget first cost if he can obtain satisfactory service.

Pittsburgh, Pa. A. F. GREAVES-WALKER,
Production Manager,
American Refractories Co.

Method of Removing Broken Stud Bolts

After reading the article on removing broken stud bolts, page 111 of the Jan. 17 issue, by C. A. Atkins, I thought some of the younger readers of *Power* would be interested in a much more convenient arrangement for doing such a job.

Mr. Atkins states that the two stud bolts were broken off flush. When that is the case, a good plan is to leave the cylinder head in place and use an "old man," *A* or *B*, as shown in the sketch, securing it to the nearest stud, and to use a drill of the same size as the hole in the



ANOTHER WAY OF DRILLING OUT BROKEN STUD BOLTS

head to start the drilling. This will insure drilling in the center of the broken stud, as the drill is guided centrally by this hole. Drill just sufficiently to get a good center in the studs. Then change the drill to the proper size that will leave a shell on the stud, which is backed out by Mr. Atkins' method.

Should the thin shell fail to back out, there is the dead center of the stud hole to use as a guide in drilling with a tap-size drill; then retap the hole. If the hole is drilled in Mr. Atkins' way and the studs do not come out, and the hole is drilled to one side of the stud, there is likely to be trouble, as it will be necessary to drill out the stud anyway, and in so doing the threads will be cut out on one side of the hole in the engine casting, which will ruin the hole. It will then be necessary to drill and tap it larger for the next size stud.

Drilling out a broken stud in an engine is a somewhat important job and should be done carefully. If, in using Mr. Atkins' method, one of the nuts on the crossbar is tightened more than the other, the drill would surely be thrown out of line.

Mr. Atkins, having a ratchet and drill and a blacksmith shop available, could have saved time, labor and expense by having the blacksmith shape up a piece of iron ¾ x 2 in., or something near that, of the shape shown in sketch *C*. It would have been handier and better, and it would have held the ratchet firmly in place. Besides, one man could then do the job, whereas it looks like a two-man job to put up his rig.

West Concord, N. H. CHARLES H. WILLEY.

Central Heating by Gas Producers

The article, "Central Heating by Steam, Water or Gas," by Mr. Samuel R. Lewis of Lewis & Capron Company, consulting engineers, Chicago, in the Feb. 14 issue of POWER, was extremely interesting. I have long felt that the application of producer gas to this class of work would prove a great saving in first and operating costs.

Great care must be exercised in designing and the selection of equipment for a plant of this nature, and even then the problem of operation is very perplexing and must be considered carefully from every point of view before choice is made.

My experience, which has been quite varied with this equipment, tends to discredit the advisability of installing the up-draft type of producer, for as yet the troubles from tar have never been overcome. It is next to impossible to eliminate all the tar and tar oils that eventually find their way into the distribution piping and burners.

After studying the reasons why tar, water and other foreign matter were troublesome components of the gas and experimenting on how to overcome these evils, I would like to pass along some of my findings.

No tar extractor is 100 per cent perfect, and tar will pass with the gas into the piping system.

The cooling towers, which are generally connected between the tar extractors and the distributing system, are in most instances served with water of too high a temperature, the gas leaving the towers twenty to fifty degrees above the prevailing atmospheric temperature. This allows the gas to carry with it moisture several points in excess of the saturation point at the temperature leaving the washer, or cooling tower. Assume, for instance, using air as a basis, that the gas leaving the scrubber, or cooling tower, has a temperature of 102 deg. F., that the piping of the system is buried and that the temperature of the ground in winter months at 4-ft. depth is 45 deg. F. The gas leaving the scrubber will under these conditions contain approximately 0.003 lb. of water per cubic foot, while at the 45 deg. it will only carry 0.0005 lb. of water per cubic foot. The difference, or 0.0025 lb., will be precipitated in the piping system, and provision must be made to care for this condensation as it carries with it considerable foreign matter and tar. This will amount to about 1,700 to 2,000 lb. of condensate and foreign matter per hour in the plant referred to in this article.

The gas will be of a varying heat value and chemical composition, requiring a varying air supply for correct combustion, and this is quite hard to overcome by automatic regulation or by automatically regulating the quantity used by the demands on the heating boiler. I have found that the matter of correct air supply under these varying conditions is difficult to overcome and requires considerable adjusting of burners for the changing values of the gas. This will be especially noticeable where only one producer is operating.

The fuel used, although not bearing directly on the troubles from tar and water in the gas, will have a direct bearing on the quality and consistency of the gas produced.

It is well known that fuels gasified in a producer are subject to a steam-air blast, and a coal that is non-caking, low in sulphur and low in ash and that will not clinker readily at low temperatures is very desirable.

The writer has looked forward to a day when he could interest someone in the building of what seems to be the one best system of making producer gas; that is, by the combined down-draft producer and boiler where the sensible heat of the gas would be utilized in making steam for the air saturation and other auxiliary equipment, while the exhausters could be operated by gas engines with as much of the waste heat of the producer and engine as possible returned to the producer in the air supply.

This would require a radical change in down-draft producer design and in producer-plant design in general, but would be very efficient and could be made to generate tar-free gas, which after all is the one big thing to do.

A plant constructed along these lines could be made to serve the small as well as the large towns and cities, furnishing producer gas for domestic uses such as cooking, lighting and heating. All will agree that the gas-fired heating plant, whether it be a hot air, hot water or steam plant, is much more efficient than the coal-fired one. It is believed that the average home could be heated for less money by producer gas than could be expected by direct firing, and the convenience and ease of control would be of advantage. There would be no ashes, no coal bins, no dust and no smoke to contend with.

After giving the manufacture, cleaning and distribution of producer gas very careful and thorough study, I believe that it will come into very general use in the future for domestic purposes, and await the day that I may set out to perfect such a plant and system.

W. G. WEBSTER,
Engineer—Works Engineering Division,
Detroit, Mich. Maxwell Motor Corporation.

Evaporation of Oil

In the Feb. 7 issue of *Power*, W. F. Osborne, writing on the subject "Lubrication—Evaporation of Oil" states that "a unit volume of air at any given temperature will hold only a definite amount of oil vapor, depending upon the vapor pressure of the oil. Raising the temperature of the air expands it and permits it to hold more vapor."

Here is an expression that implies that the density of air, aside from its temperature, determines the amount of vapor that can be carried in a unit volume. The idea is quite prevalent that air carries water in the same manner as does a sponge. As a matter of fact, vapor fills a space entirely independently of the presence of the air.

If the facts were as quoted, then the mere increase of temperature of air from 32 to 102 deg., causing an expansion of 14 per cent, would increase the water-carrying capacity from 0.000435 lb. to 0.002999 lb. per cu.ft., or 590 per cent. Of course the expansion of air, unless accompanied by a change in temperature, has no effect on its vapor-carrying capacity. Incidentally, "vapor-carrying capacity" is a misnomer, and this phrase is probably responsible for the impression that air carries vapor as a sponge carries water. As stated, the presence of the air has nothing to do with the amount of vapor in a given space, this being governed entirely by temperature.

Imagine a vessel half-full of water; the vapor above the surface has a certain tension (pressure would be the more understandable term). Remove the air. You have reduced the total pressure, but have not affected the vapor tension because the temperature has not been changed. Now apply heat to the water. There is an increase in the velocity of the molecules, and a greater number pass up into the vapor space. This increases as the temperature is increased until saturation is reached. Saturation is a condition of stability caused by the number of molecules returning to the water equaling the number leaving.

C. O. SANDSTROM.
Kansas City, Mo.

Simplifying Locating Trouble on Electric Circuits

Mr. Armstrong's comment on page 317, Feb. 21 issue, on the article "Simplifying Locating Trouble on Electric Circuits" in *Power* for Feb. 7 seems to open a channel for argument regarding the possibility of attaining perfection in the installation of electrical apparatus. Methods now in vogue in the construction of power plants have changed considerably in the last twenty-five or thirty years. It was formerly customary to build a plant in its entirety before placing it in service, whereas today it is a rare occurrence for a plant to be finished before it is put to use; in fact, the usual method is to put each unit in service as soon as it is ready to go into operation.

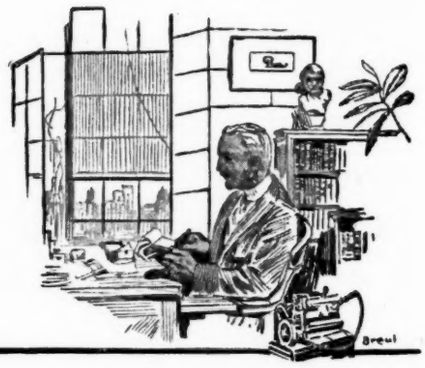
One unit may be ready for service, so it is put in operation with a few tests to show that it will function properly; the final tests to be made when the plant is finished, probably some months after. Other units and their auxiliaries are put in service just as soon as the construction force is through with them and in many cases before they are quite finished. Under such conditions everybody connected with the plant is under pressure, not that any specific call is made to hurry, but there is a feeling throughout the whole organization that each individual must hasten or he will interfere with those who follow.

This is not an argument in favor of careless work, but it is plain that any class of work will suffer when carried on under pressure. An occasional piece of conduit will get by without the ends being reamed, wire that has been kinked will be pulled into the ducts, joints will be improperly taped and all sorts of things will happen which will develop trouble after a time in service, and when that trouble occurs there will be less time lost if the way has been prepared as suggested in the article mentioned.

There is no intention in this article to be pessimistic with regard to the manner in which power-plant work is managed or executed, but it is desired to bring out the fact that poor work does get by the most vigilant inspectors and careful workmen, and the comparatively slight expense of the additional material and labor needed to provide a means of facilitating the work of fault-location may be regarded as paid up insurance on continuity of service rather than an added burden on the cost of installation.

HAROLD R. HUTCHINSON.
Cambridge, Mass.

QUESTIONS AND ANSWERS



Extra-Heavy Pipe Beyond Blowoff Valves

Directly to the rear of our two horizontal return-tubular boilers is a blowoff tank that is set centrally between the boilers and about 20 in. from the rear wall. Extra-heavy pipe is used from each boiler to its blowoff valves. Should the piping from the valves to the tank be extra-heavy? W. M. T.

Extra-heavy pipe beyond the blowoff valves is not necessary for the safety of the boilers, but should be used in preference to standard pipe, as a greater precaution against dangers from breakage or corrosion.

Removing Scale from Water Jacket

How can a gas-engine water jacket be cleaned of scale deposited out of the cooling-water? D. L. S.

The scale deposited out of most cooling waters can be removed by a solution of commercial muriatic acid and an equal quantity of water. Care should be taken that the solvent action of the acid is not continued to the extent of injuriously corroding the walls of the water jacket or other parts of the engine. After application of the acid solution, the parts that have come in contact with it should be thoroughly washed with clean water.

Expansion of Superheated Steam Line

What will be the expansion of a steam pipe line 200 ft. long, when delivering steam at 150 lb. gage pressure, superheated 100 deg. F., if the line is erected when the temperature is 60 deg. F? F. A. N.

The temperature of saturated steam at the pressure of 150 lb. gage, or 165 absolute, is 366 deg. F., and when superheated 100 deg. F., the temperature would be 466 deg. F. Assuming that the whole line is heated to that temperature, the change throughout would be 466 — 60 = 406 deg. F. The coefficient of expansion for steel or wrought iron is about 0.0000065, and the expansion would be $406 \times 200 \times 0.0000065 = 0.5278$ ft. or about 6⅜ inches.

Reversing Direction of Alternator

If the direction of rotation of a two-phase or three-phase alternator is reversed, what effect will it have upon the power system it is supplying? W. P. S.

Reversing the direction of the machine will reverse its phase rotation, and if connected to a system supplying polyphase motors, these will also be reversed. When the direction of rotation of the alternator is reversed, the leads of one phase should be crossed to give correct phase rotation. In a three-phase machine this can be done by crossing any two leads, and on a two-phase machine by interchanging the two leads from either phase. If the machine had been operating in parallel with other alternators before it was reversed, after reversal it will be found necessary to cross the leads on one phase before the machine can be again paralleled with the other machines.

Brass versus Babbitted Boxes

What are the relative merits of babbitt-lined brasses and boxes of solid brass for the crankpin end and the crosshead end of the connecting rods of Corliss engines running 70 to 80 r.p.m? H. B. P.

Until recent years brass was used exclusively as the material for boxes. Now the boxes usually are made of brass, lined with a white bearing metal. Babbitted bearings have the advantage of being more easily fitted by scraping, and of melting out before serious cutting occurs to the pin from presence of dirt or from over heating. To bring brass to a good bearing requires greater skill in fitting and scraping, and there is more danger of the pin becoming scored from cutting, without warning.

Explosions in Compressed-Air Systems

What causes fire and explosion in a compressed-air system? W. L. N.

The air itself is not inflammable, but when air is compressed by piston compressors, it is necessary to use cylinder lubricating oil, and this oil, or the gases from it, forms with air a combustible mixture that, in the process of compression, attains high enough temperature for its ignition, due to a leaky discharge valve. Hence ignition usually occurs at the compressor, from which fire may extend through the system and the sudden expansion of the air from the heat of the combustion may result in violent explosions of receivers and other containers of the compressed air. Firing is more likely to occur from use of a cylinder oil of too low flash point, and in some cases it results from the use of too much oil.

Pounding of Engine After Reversing

We operate a 28 x 48-in. Corliss engine that has been running over for 15 years and recently had to reverse the engine; that is, it now runs under. The engine has a loud knock in the main journal bearing. How can we get rid of the trouble? F. C.

When running over, transmission of the load from the piston to the connecting rod causes the crosshead to exert pressure on the lower guide in addition to the pressure from the weight of the crosshead and connected parts. When the engine was reversed, the pres-

sure of the crosshead, less the pressure due to the weights, was transferred to the upper guide. Hence, in running under the crosshead is not held as rigidly to the guide, and that may be the initial cause of pounding, which is taken up by the main bearing. The remedy for this trouble from the crosshead would be to obtain good alignment of the guides and center the crosshead with the least possible clearance between the crosshead and guides consistent with maintaining good lubrication of the upper guide.

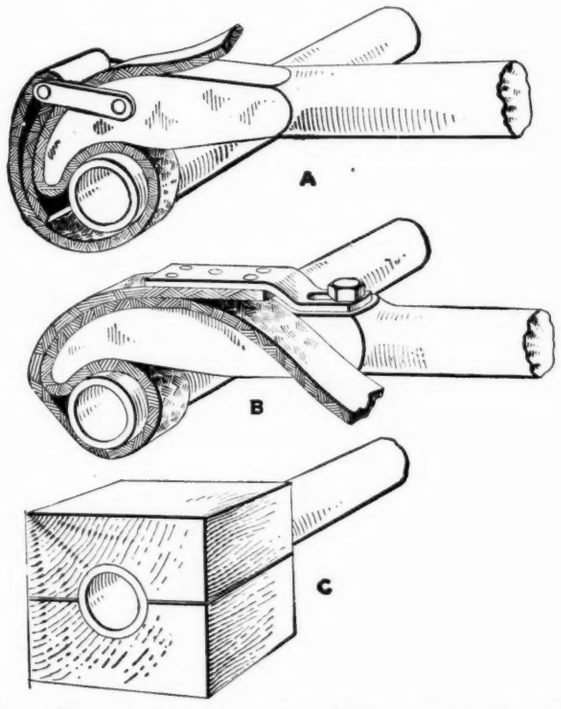
From long time running, the crosshead pin, crankpin and main journal and their bearings would become worn out of round, and from reversing the engine there would be opposite direction of wear and different distribution of pressure, and if the pins, main journal and all bearings have not been trued up since the engine was run over, those repairs should be made before it can be expected to get rid of the knock in the main bearings by simply adjusting the crosshead.

Running Brass Feed Lines

We have about 200 ft. of 2-in. brass pipe to be connected up for boiler-feed lines. What is the best kind of tools to use in place of ordinary pipe tongs and vise that would cut and flatten the brass, which is much softer than steel or iron pipe; and in screwing together the pipe, should it be set up as hard as steel pipe?

W. J. G.

Dealers in plumbers' and pipefitters' tools supply brass-pipe wrenches that generally go by the name of "strap" wrenches of suitable design for grasping the



pipe with a stout strap of leather or heavy webbing wrapped around the pipe. A standard form of strap wrench is shown in the sketch at *A*, in which the outer loop of the strap is passed through a clevis attached to the wrench and the end of the strap is returned under the loop. A "home-made" form is shown at *B*, in which the end of the outer loop is riveted to a piece of flat iron caught by a setscrew. Use powdered rosin to prevent the strap from slipping on the pipe.

To hold the pipe in a vise, provide a pair of clamps as shown at *C*, made from a solid block of wood bored with a hole the exact outside diameter of the pipe, and split the block with a saw cut as indicated.

In using means to prevent brass pipe from crushing, the joints usually cannot be set up so hard as when screwing up steel pipe, and to insure tight joints, greater care should be taken to have the screw threads of pipe and fittings of good form and well matched.

Mechanical Efficiency of Engine

What is the mechanical efficiency and brake horsepower of an engine, when there is development of 142 indicated horsepower and with no load on the engine there is development of 19.5 indicated horsepower?

L. M.

The mechanical efficiency of an engine, or its efficiency considered simply as a machine, is the ratio of the brake horsepower to the indicated horsepower that must be developed for production of the brake power; or stated as a formula,

$$\text{Mechanical Efficiency} = \frac{b.hp.}{i.hp.}$$

The difference between the indicated horsepower and the brake horsepower is the amount of power required to overcome friction. With most steam engines this difference, called the friction horsepower, is practically constant for all loads from 0 to full load, and the brake horsepower developed for any indicated power is assumed to be the indicated horsepower minus the friction horsepower, or horsepower indicated when the engine runs at its regular speed with no load. Hence in the example, b.hp. = 142 — 19.5, or 122.5, and mechanical

$$\text{efficiency} = \frac{b.hp.}{i.hp.} = \frac{142 - 19.5}{142} = 0.86.$$

Effects of Power Factor on Electrical Power Generation

In the operation of a steam-engine driven generator operating at full kilovolt-ampere load, will the steam consumption be the same per kilowatt-hour output at low power factor as at unity power factor? D. C.

The steam consumption will be higher per kilowatt-hour output for the low-power-factor load. Assume that the load has a power factor of 0.50. Then when the generator is loaded to full kilovolt-ampere rating it will only be delivering 50 per cent of its kilowatt rating at unity-power-factor load. Now, the kilowatts is what represents the load on the engine, consequently the engine at 0.50 power-factor load is only 50 per cent loaded and is therefore operating considerably below its best water rate, which is one reason why the steam consumption will be higher. To obtain 50 per cent of the generator's rating in kilowatts, 100 per cent full-load current is flowing in the armature windings. Therefore, the copper losses are about double what they should be for 50 per cent load at unity power factor, and the other losses in the machine about the same as at full load kilowatts, these also increase the steam consumption. When the generator is supplying a load of low lagging power factor it will require a greater current in the field coils than at unity power factor.

[Correspondents sending us inquiries should sign communications with full names and addresses.—Editor.]

News in the Field of Power

De Lamater-Ericsson Tablets Unveiled with Ceremony

With appropriate speeches, music, decorations, congratulations, and other customary features of such public ceremonies, four bronze tablets commemorating the accomplishments of Captain John Ericsson and Cornelius H. De Lamater were unveiled in New York City March 9, the sixtieth anniversary of the victory won by the "Monitor," which was built by these two men, over the "Merrimac." The four ceremonies took place according to schedule, as announced in *Power* for March 7.

A feature of the unveiling at Cunard Pier 54, the site of the old De Lamater Iron Works, was a speech by the Hon. Charles Vezin, Jr., a grandson of Mr. De Lamater. Speaking of the Associated Veterans of the De Lamater Iron Works, which organization arranged for this tablet, he said that the continued loyalty of these men to the ideals of the old company, whose existence ended 32 years ago, ought to have deep significance to the employers and employees of today.

New Yorker Wants State To Develop Water Power

A bill that is perhaps the largest appropriation measure ever put before a state legislature was introduced recently into the New York State Legislature by Assemblyman James Male.

It provides for the appropriation and expenditure of $700,000,000 in the development of hydro-electric power, the erection of gas-producing plants and the transmission of water from the Adirondack and Catskill mountain lakes to the nearby territory.

The distinctive feature of the measure is that it calls the bluff of the politicians who for a dozen years have been playing with the question of hydro-electrical development in New York State, and introducing measures calling for one and two million dollar appropriations. It sets before the legislature and the people exactly what state-wide development of such natural resources would ultimately cost, or at least gives a fair idea of it.

The $700,000,000, under the proposed measure, is not all to be spent in one year. It is to be raised and used at the rate of $35,000,000 each year for twenty years, at the end of which time a comprehensive system would be in effect if the bill should be passed, and all private capital would by that time have been confiscated.

The measure provides for the ultimate construction in each county of a hydro-electric plant, if there be undeveloped water power owned by the state in such county, and for the erection in each county of at least one gas-manufacturing plant and the sale of the product to the public, to municipal corporations and to public service corporations at cost, with a restricted resale price of two per cent above the price paid to the state. No mention is made of investigating the market for power in each county, that being taken for granted.

While there is absolutely no chance of any consideration of the bill, it represents the first comprehensively drawn hydro-electric and utility development bill that has been introduced in the legislature of New York State. It tells the people exactly what the proposition of such development amounts to.

Rochester Engineers to Celebrate Quarter-Centennial

A joint anniversary dinner in celebration of the quarter-centennial of the Rochester Engineering Society will be held at 6:30 p.m., March 18, in the ball room of the Powers Hotel, Rochester, and will include as its principal feature an address on "Engineering Observations in China and the Far East," by John R. Freeman, president of the American Society of Civil Engineers and past president of the American Society of Mechanical Engineers. Mr. Freeman is an authority upon hydraulic engineering, and will be remembered for his report of 1908 on the Genesee power project at Portage, N. Y.

The chairman of the Ticket Committee is Frank T. Byrne, 49 Stone St., Rochester, and he suggests that applications for tickets be sent promptly.

The societies that will participate are the Rochester Engineering Society, the Rochester Society of Architects, the Society of Technical Draftsmen, and Rochester Sections of the A.A.E., the A.I.E.E., the A.S.M.E., the American Legion and the American Society for Steel Treating.

A. I. E. E. Picks Chicago and Niagara Falls for Conventions

The American Institute of Electrical Engineers has announced the preliminary plans for its two coming conventions.

The Spring Convention will be held April 19-21 at the Drake Hotel in Chicago. The program has not yet been arranged, but four papers that will probably be given are: "The Superpower System," by Henry Flood, Jr.; the same, by L. E. Imlay; "The St. Lawrence Seaway," by W. L. Saunders; and "Electric Power Application to Passenger and Freight Elevators," by H. P. Reed.

The Annual Convention will be held this year at Niagara Falls, in the week of June 26-30, with headquarters at the Clifton Hotel. The program is being arranged but no papers have yet been announced.

Society Affairs

Coming Conventions

American Institute of Electrical Engineers — Spring Convention at Chicago, April 19-21. Headquarters, 29 West 39th St., New York City.

American Society of Mechanical Engineers — Spring Meeting at Atlanta, Ga., May 8-11. Secy., Calvin W. Rice, 29 West 39th St., New York City.

National Electric Light Association —Annual convention at Atlantic City, N. J., May 15-20. Headquarters, 29 West 39th St., New York City.

Cleveland Section, A.I.E.E., will hold a meeting March 21 to discuss "Power Plant Economics with Special Reference to the Steam Turbine," by T. E. Keating, of the Westinghouse Co.

Chicago Section, A.S.M.E., will meet March 20 for an address on "Conservation of Heat in Heating and Power Systems," by Dr. Edwin R. Weidlein, director of Mellen Institute.

Philadelphia Sections of the A.S.M.E., the A.I.E.E. and the A.S.C.E., and the Engineers Club of Philadelphia, will hold a joint meeting March 21 with the co-operation of the Hydro-Electric Power Commission of Ontario. It will be in the nature of a hydro-electric symposium dealing with the Chippawa-Queenston development, especially the 55,000-hp. waterwheels that were put in operation in January.

Personals

T. C. Greene, for many years with the Garlock Packing Co., has resigned to become general manager of the John F. Robertson Co., Pittsburgh, Pa., manufacturers of power plant equipment.

Prof. Edwin Allen Fessenden, since 1916 professor of mechanical engineering and head of the department of mechanical engineering in Pennsylvania State College, has accepted the same position in Rensselaer Polytechnic Institute, Troy, New York. His research work has included a study of the weathering of coal and of heat transfer in boilers at the Engineering Experiment Station, University of Missouri.

W. M. White, manager and chief engineer of the hydraulic department of the Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has returned recently from a six months' trip to the Orient. He called upon many of the Japanese engineers who had visited Milwaukee in recent years concerning hydro-electric development, and, incidentally, concluded arrangements for the construction of four 18,000-hp. turbines to be installed in the power house at the Oi development on the Kiso River for the Daido Denryoku, of Nagoya, Japan. A

brief outline of the general power situation in Japan and Formosa, prepared by Mr. White, appears on another page of this issue.

Business Items

McLeod & Henry Co., Troy, N. Y., are putting out a new product called "Steel Mixture" Fire Cement for use in boiler fittings. This company has been experimenting for some time with this new cement.

Alvord & Burdick, consulting engineers, of Chicago, have announced a change in the firm name to Alvord, Burdick & Howson. Mr. Howson has been for fifteen years with the firm, which handles work on water works, power plants, etc.

The Hardinge Co., 120 Broadway, New York, N. Y., has taken over the manufacture of the coal-washing equipment formerly made by the Coal Washing Equipment Company of Pottsville, Penn., the equipment consisting mainly of the James automatic balanced jig.

The Godfrey Co., Elkhart, Ind., has announced that R. W. Mongor, of Elkhart, has bought a controlling interest in the company and was elected president at a recent meeting of the board of directors. The other officers elected were B. C. Godfrey, vice president; D. H. Hebster, treasurer; and Charles E. Clouse, secretary. The board of directors includes the officers and James H. Cannon and Fred W. Reid.

The Keystone Refractories Co., 120-122 Liberty St., New York City, has been organized by F. W. Reisman and L. E. Turk, who were formerly traveling sales manager and treasurer, respectively, of the Quigley Furnace Specialties Co., of New York City. They are to engage in the manufacture of high-temperature cements and granular refractories at their factory in Jersey City, N. J.

Trade Catalogs

Pulverized Fuel for Locomotives—Combustion Engineering Corporation, Broad Street, New York City. Valuable test figures are given on the actual performance of pulverized fuel installations in a number of different locomotives.

Boiler Feed Meters—Simplex Valve and Meter Co., 5722 Race St., Philadelphia, Penn. A short bulletin explaining the need for keeping an accurate record of the water fed to boilers, and describing the company's recording boiler-feed meter.

Water Waste Surveys — Simplex Valve and Meter Co., 5722 Race St., Philadelphia, Penn. A short bulletin describing the method of finding waste in piping systems by means of the company's Pitot tube, portable manometer and portable chart recorder.

General Tools—Mound Tool Co., St. Louis, Mo. Catalog No. 7, a handsome two-color 60-page catalog, showing the full line of Mound tools for the engineer, mechanic and autoist. The various sizes and the prices of each tool are listed, and an index makes it possible to find quickly and easily the desired product.

Stokers — Combustion Engineering Corporation, Broad St., New York City. A short bulletin on the Type K automatic stoker, for boilers up to 2,000 sq.ft. of surface. Several improvements in the design of this stoker have been made since it was brought out two years ago, and they are covered in this bulletin.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Feb. 27, 1922	Marh 6, 1922
Pool 1,	New York	$3.00	$2.75@3.25
Pocahontas,	Columbus	2.15	1.75@2.00
Clearfield,	Boston	1.95	1.65@2.25
Somerset,	Boston	1.90	1.75@2.00
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	1.60	1.50@1.75
Hocking,	Columbus	1.90	1.75@2.00
Pittsburgh No. 8	Cleveland	2.00	1.95@2.00
Franklin, Ill.,	Chicago	2.50	2.25@2.75
Central, Ill.,	Chicago	2.35	2.25@2.50
Ind. 4th Vein,	Chicago	2.50	2.35@2.65
Standard,	St. Louis	1.95	1.85@2.00
West Ky.,	Louisville	1.85	1.70@2.00
Big Seam,	Birmingham	1.85	1.70@2.00
S. E. Ky.,	Louisville	1.55	1.50@1.65

New York—On Mar. 8, Port Arthur light oil 22@25 deg. Baumé 4c. per gal. 30@35 deg., 5c. per gal., f.o.b. Bayonne, N. J.

Chicago—Mar. 8, for 24@28 deg. Baumé, 85@90c. per bbl.; 32@36 deg., 2⅜@2½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Mar. 7, f.o.b. refinery, Pennsylvania, 38@40 deg. 4¼c. Kentucky fuel oil, 26@30 deg., 3c. per gal. Western, 24@30 deg., 80c. per bbl.; 32@34 deg., 2¾c.; 36@38 deg., 3c.; 38@40 deg., 3¼c. per gal.

St. Louis—Mar. 4, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 85c. per bbl.; 26@28 deg., 90c.; 28@30 deg., $1.00; 32@34 deg., 2¾c. per gal.

Philadelphia—On Mar. 6, 26@28 deg. Baumé, Oklahoma, 75@80c. per bbl.; 30@34 deg., Oklahoma (group 3) 2¼@2¾c. per gal.; 16@20 deg., Seaboard, $1.20@1.25 per bbl.

Cincinnati—Feb. 27, for 26@30 deg. Baumé, 5c.; Diesel 32@34 deg., 5¼c. per gal.; distillate 38@46 deg., 6c. per gal.

New Plant Construction

PROPOSED WORK

Cal., Oakland—The city is having plans prepared for a 2 or 3 story high school on University high school site. About $500,000. Construction Dept., Chabot Hall, 11th & Jefferson Sts., Bd. of Educ., c/o C. W. Dickey, Archts.

Cal., Palo Alto—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids until April 10 for mechanical equipment in 19 buildings of the United States Veterans Hospital, here. About $250,000.

Cal., San Francisco—The Bd. Public Wks. will receive bids until April 12 for Contract No. 79-Hetch Hetchy Water Project, Section A; 2, 3 or 4, 25,000 hp. double overhung impulse water wheel units, each to drive a 20,000 kva. electric generator. Section B; 4, 6 or 8, 36 in. valves, 2 for each water wheel unit; Contract No. 180 furnishing and delivering electric generators and accessory equipment for Moccasin Creek Power Plant. M. M. O'Shaughnessy, City Hall, Engr.

Fla., Safety Harbor—The city, A. E. Shower, Town Clk., plans election to vote $10,000 bonds for addition to electric lighting plant.

Ga., Wrightville—The Southern Ice & Coal Co., is in the market for a 6 x 6 duplex, belt driven air compressor that will lift water from deep well which has water level of about 60 ft.

Ia., Waterloo—The Roth Packing Co. is having plans prepared for a 1 story, 24 x 400 ft. power plant to include two 200-ft. smokestacks and two 500 hp. boilers. About $60,000. Private plans.

Ill., Astoria—Canton Archl. Co., Engrs., Ellis Bldg., Canton, representing a company now forming, is preparing plans for a coal mine tipple, power house, etc. About $300,000.

Ill., Beardstown—The Bd. Educ., C. J. White, Pres., is having plans prepared for a 4 story high school including a steam heating system. About $300,000. M. J. Geist, 6th and Main Sts., Quincy, Archts. Noted Jan. 24.

Ill., Chicago—The Amer. Bread Wrapper Co., 361 East Ohio St., is in the market for a 15 hp. gas boiler.

Ill., Chicago — A. S. Hecht, Archt., 155 North Clark St., is receiving bids for three apartments, one 150 x 208 ft. on Paxton Ave., near 68th St., about $275,000; one 150 x 280 ft. on Paxton Ave. near 67th St., about $275,000; and one 100 x 150 ft. on Blackstone Ave. near 56th St., about $250,000, all 3 story, for H. F. Bloom, care of architect. Steam heating systems will be installed.

Ill., Chicago—Holabird & Roche, Archts., 104 South Michigan Ave., are receiving bids for a 25 story, 173 x 402 ft. hotel "Stevens" including a steam heating system on Michigan Blvd. between 7th and 8th Sts., for J. W. and E. J. Stevens, c/o Hotel, LaSalle. About $15,000,000.

Ill., Chicago—The Y. M. C. A., 19 South LaSalle St., plans to build a 5 story, 127 x 140 ft. Y. M. C. A. building, including a steam heating system on 53rd St. and Dorchester Ave. About $400,000. Architect not selected.

Ill., Cicero—The Dearborn Truck Co., 1301 South Cicero Ave., is in the market for an air compressor, direct motor or belt driven, capacity not less than 140 cu.ft.

Ill., Elgin—The Elgin Coal & Ice Co., W. H. Parked, 162 Milwaukee St., plans to build a 3 story ice plant. About $75,000. Architect not selected.

Ill., Marengo—The Elgin & Marengo R. R. Co. is having plans prepared for a 42 x 126 ft. power plant. About $50,000. The Arnold Co., 105 South LaSalle St., Chicago, Engrs.

Ill., Rockford—The Bd. Educ., E. E. Lewis, Supt., will receive bids until April 5 for a 3 story junior high school including a steam heating system Hockell Ave. About $650,000. Peterson & Johnson,

Swedish American Bank Bldg., Archts. Noted Jan. 31.

Ind., Ft. Wayne—Day & Zimmerman, Engrs., 608 Chestnut St., Phila., Pa., are receiving bids for an automobile factory to include power house and offices for the International Harvester Co., 114 West Wayne St. About $500,000.

Kan., Atchison—The Mt. Scholastica Academy, 8th and Eccher Sts., will soon receive bids for a 4 story academy. About $600,000. E. Brielmaier & Sons, 432 Bway., Milwaukee, Wis., Archts.

Mass., Boston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until March 29 for coal handling equipment. Spec. 4583.

Mass., Scituate—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for a radio compass station, Fourth Cliff, Barricks Bldg. from W. F. Martens, 53 Franklin St., Rochester, N. Y., $13,848; M. Serretto, 3 Fremont Row, Boston, $14,400; and the Beacon Constr. Co., 15 Beacon St., Boston, $14,693. Spec. 4568.

Mich., Detroit—The Dept. of Motor Transportation, City Hall, plans to build a 1 story garage and service station including a steam heating plant on Jefferson Ave. About $560,000. Engineering Dept., Street Railway Comn., Marquette Bldg., Engrs.

Mich., Grand Rapids—Coolidge & Hogdon, Archts., 134 South LaSalle St., are receiving bids for a 2 story, 90 x 102 ft. church including a steam heating system for the Fountain St. Baptist Church, 438 Terrace St. About $500,000. Noted June 7.

Neb., Bethany—The city, C. W. McIntyre, Clk., will receive bids until March 16 for a reservoir and two pumps, capacity 100 gal. per min. About $7,000. A. H. Edgren, Lincoln, Engr.

N. H., Laconia—The city will receive bids about April 1 for a 2 story, 123 x 164 ft. high school on Union Ave. About $400,000. P. S. Avery, 99 Chauncy St., Boston, Mass., Archt.

N. Y., New York—C. Mark Realty Co., c/o C. Kreymborg, Archt., 2534 Marion Ave., will soon award the contract for a 5 story apartment and stores building including a steam heating system on St. Nicholas Ave. About $350,000.

N. Y., New York—The Metropolitan Tabernacle, O. E. Konkle, Chn., 3 West 95th St., is having plans prepared for a 17 story hotel on Bway. and 104th St. About $1,500,000. Carrere & Hastings, 52 Vanderbilt Ave., Archts. and Engrs.

N. Y., Portchester—M. Dileo, Westchester Ave., is having plans prepared for an 80 x 130—300 tons capacity coal bunker at coal plant. Coal handling machinery will be required. About $25,000. F. Urso, 453 West Main St., Stamford, Conn., Engr.

N. Y., Rochester—Berger Bros., 39 North Water St., are in the market for small electric motors of various sizes.

N. Y., Watertown—The city council plans election to vote $500,000 bond issue for development of municipal water power. R. E. Cahill, Mayor. Noted April 19.

N. C., Asheville—The North Carolina Electrical Power Co. plans to install 1,200 hp. turbine at Weaver power plant at Craggy, $200,000; also an 8,000 hp. steam turbine at Elk Mountain steam plant, $100,000. C. E. Waddell, Asheville, Engr.

N. C., High Point—The Commercial Natl. Bank will soon award the contract for a 10 story, 50 x 115 ft. bank and office building. About $1,000,000. C. G. Hartman, 207 West Sycamore St., Greensboro, Archt. and Engr. Noted Nov. 8.

N. D., Fargo—The city, A. R. Watkins, Clk., is having plans prepared for addition to and remodeling filtration plant, also installing reservoir, settling basin and pumping station. About $40,000. R. T. Jacobsen, Fargo, Engr.

O., Cleveland—J. S. Adams and E. B. Thomas, 1012 Natl. City Bldg., representing owners, are having plans prepared for a 3 story, 130 x 210 ft. apartment including a steam heating system on Shaker Blvd. and East 127th St. About $300,000. S. H. White, Schofield Bldg., Archt.

O., Columbus—I. L. Oppenheimer, Louisville, Ky., is having sketches made for a 12 story, 74 x 84 ft. hotel on West Scott St. About $400,000. F. L. Packard, New Hayden Bldg., Archt.

O., Dayton—The Dayton Hydraulic Co., Winters Bank Bldg., plans hydraulic power canal. About $300,000.

O., East Cleveland (Cleveland P. O.)—The Bd. Educ., C. B. Tilden, Dir., is having plans prepared for a 1 story, 65 x 200 ft. school and 75 x 80 ft. power plant on Caledonia Ave. About $150,000. Cavanaugh & Baer, 2725 Prospect Ave., Cleveland, Archts.

O., East Liverpool—The Buckeye Lumber & Bldg. Co. is in the market for a 25 or 30 hp. standard gas engine.

O., Lakewood (Cleveland P. O.)—P. M. Platten, 348 B. of L. E. Bldg., Cleveland, is having plans prepared for a 4 story, 150 x 210 ft. apartment including a steam heating system on Detroit and Giel Aves. About $300,000. J. L. Cameron, 10406 Euclid Ave., Cleveland, Archt.

Okla., Wilburton—The city is having preliminary plans prepared for a 700,000 G. P. D. filter plant, low head diversion dam, low lift pump station, remodeling pump plant and distribution system. About $92,000. V. V. Long & Co., Colcord Bldg., Oklahoma City, Engr.

Pa., Erie—The council is receiving bids for a 20,000 gal. storage tank and a 40 hp. tubular horizontal return boiler.

Pa., Phila.—The Bd. Educ., 19th and Chestnut Sts., is having plans prepared for a junior high school on 54th St. and Warrington Ave., about $300,000; a 3 story junior high school on Ridge Ave. and Fountain St., about $800,000; two elementary schools, one on 65th St. and Lansdowne Ave., and one on 3rd and Duncannon Sts., about $400,000 and $300,000 respectively. Private plans.

Pa., Phila.—J. J. Greenberg, c/o L. B. Rothchild, Archt., 12th and Sansom Sts., is having plans prepared for an 8 story, 102 x 180 ft. warehouse on 24th and Walnut Sts. About $500,000.

Pa., Phila.—The Insurance Co. of North America, 3rd and Walnut Sts., plans to build a 10 story, 147 x 159 ft. office building on 16th and Arch Sts. About $1,500,000. Architect not selected.

Pa., Phila.—O. W. Ketchum, 24 South 7th St., plans to build a 9 story, 62 x 80 ft. office building at 121-28 18th St. About $500,000. Architect not selected.

Pa., Phila.—The Turner Constr. Co., Engr., 1713 Sansom St., is receiving bids for a 6 story, 117 x 125 ft. factory. About $500,000. Owner's name withheld.

Pa., Phila.—J. Thommen, 15th and Market Sts., plans to build a 10 story, 69 x 176 ft. hotel at 1714 Market St. About $1,000,000. Architect not selected.

Pa., Tamaqua—The Tamaqua Hotel Co., c/o W. A. McGonigle, plans to build a 5 story, 75 x 100 ft. hotel at 150 West Broad St. About $400,000. Ritter & Shay, North American Bldg., Phila., Archts.

Pa., Uniontown—A. Kahn, Archt., Marquette Bldg., Detroit, Mich., and H. W. Altman, Associate Archt., Uniontown, will receive bids until March 18 for an 8 story, 55 x 76 ft. department store on Main and Gallatin Sts. for the Aaron Co., Connellsville. About $400,000.

Pa., Wynnewood—The Montgomery School, c/o P. H. Clark, plans to build a 3 story school. About $1,000,000. A. H. Brockie, 1713 Sansom St., Archt.

Tenn., Memphis—Hanker & Cairns, Scimtar Bldg., will receive bids until March 20 for a 22 story, 75 x 75 ft. office building including a steam heating system on Court Ave. and Maiden Lane for R. B. Snowden, Bank of Commerce. Noted Oct. 4.

Va., Norfolk—G. B. Todd, 415-21 Union St., J. K. Martin, Purch. Agt., is in the market for a boiler with working pressure from 30 to 40 lbs. suitable for dairy.

Va., Richmond—Starrett & Van Vleck, Archts., 8 West 40th St., New York City, will receive bids until March 20 for addition to department store on 6th St. for Miller & Rhodes Co. Inc., 6th St. About $1,000,000. Noted Feb. 21.

Wis., Beaver Dam—St. Patricks Congregation, c/o A. Lust, is having plans prepared for the installation of two new boilers and new steam heating system in church. Address F. L. Kronenberg, Slichter Bldg., Madison, Engr.

Wis., Marshfield—C. E. Blodjett Hotel Co. is having plans prepared and soon receives bids for boiler and steam heating plant. G. A. Krasin, Marshfield, Engr.

Wis., Marshfield—Blum Bros. Co., 153 West 9th St., P. Blum, Pres. is in the market for 40-50 motors, electric power.

Wis., Milwaukee—Clas, Shepherd & Clas, Archts., 445 Milwaukee St., are preparing preliminary plans for an 11 story, 75 x 120 ft. hotel. About $500,000. Owner's name withheld.

Wis., Waukesha—The Manitowoc Church Furniture Co., 1214 Lincoln Ave., C. F. Schentze, Pres., is in the market for equipment and machinery for power house addition.

Ont., Fergus—Dye Intermediates, Ltd., plans to build a factory and install filtration plant and complete electrically operated equipment for making dye intermediates. Estimated cost, $40,000. J. E. Windsor, care of owner, Engr.

Ont., Komoka—The council, T. G. Turnbull, is having surveys made for an electric lighting and power distribution system. About $33,000. A. Purcell, 190 University Pl., Toronto, Engr.

Ont., London—The Utilities Comrs., are having plans prepared for a dam. About $150,000. E. V. Buchannan, Hydro Bldg., Engr.

Que., Montreal—The Dominion Wood Heel Co., 200 De La Roche St., R. L. Raymond, Purch. Agt., is in the market for 55 hp. motors.

Que., Montreal—The Institution des Souskos Muete, 3600 St. Lawrence St., is in the market for two 25 hp. steam boilers, and four 10 hp. electric motors.

Samoa, Tutuila—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans two 300 ft. radio towers, here. Spec. 4600.

CONTRACTS AWARDED

Cal., Berkeley—The University of California has awarded the contract for furnishing and installing power plant equipment for dairy power plant to C. T. Doell, 467 21st St., Oakland. Noted March 7.

Cal., El Cerrito—The Great Western Power Co., 14 Sansom St., San Francisco, has awarded the contract for a 2 story substation here to Barrett & Hilp, 918 Harrison St., San Francisco, $125,000.

Fla., Orlando—The San Juan Hotel has awarded the contract for a hotel to the Turner Constr. Co., 244 Madison Ave., New York City. About $400,000. Noted Jan. 17.

Ia., Manning—The city has awarded the contract for a pump house, 1 well, oil tank, engines and pumps to W. B. Carter, 606 United Bank Bldg., Sioux City, and Bessemer Gas Engr. Co., Omaha, Neb., $17,995. Noted Feb. 14.

Mo., Columbia—The University of Missouri has awarded the contract for a 1 story power house and heating plant at the State College to Collins Bros., 536 Rialto Bldg., Kansas City. About $150,000. Noted Feb. 7.

Mo., St. Louis—The Sisters of St. Mary, 1536 Papin St., have awarded the contract for a 7 story, 160 x 280 ft. hospital on Belleview and Clayton Rds. to Ratermann Bldg. & Constr. Co., 1943 St. Louis Ave. About $1,000,000. Noted Jan. 31.

N. Y., Brooklyn—The Brooklyn Edison Co., 360 Pearl St., has awarded the contract for furnishing and erecting two steel stacks, each 250 ft. high for new power plant, at the foot of 66th St. to Chicago Bridge & Iron Wks., 30 Church St., New York City.

N. Y., New York—The Bethlehem Engr. Corp., 527 5th Ave., will build a 12 story office building on 51st St. and Bway. About $700,000. Owner will build by day labor. A steam heating system will be installed.

N. Y., New York—Billings-Ley Holding Co., c/o J. F. Meehan and W. C. Martin, Archts., Times Bldg., 42nd St. and Bway., will build an apartment on Grand Concourse and 172nd St. About $1,000,000.

N. Y., New York—The Ramsay Realty Co., c/o H. L. Young, Archt. and Engr., 253 West 42nd St., will build a 6 story, 93 x 167 ft. apartment at 940 St. Nicholas Ave. About $450,000. Owner will build by day labor. A steam heating system will be installed.

N. Y., Olean—The Vacuum Oil Co. has awarded the contract for a boiler house, transil oil building and loading platforms, pump house, etc., to the White Constr. Co., 95 Madison Ave., New York City. About $1,000,000.

N. C., Davidson—Davidson College has awarded the contract for a dormitory building to Blythe & Isenkour, Realty Bldg., Charlotte. About $335,000. A steam heating system will be installed.

O., Dayton—The Terminal Ice & Cold Storage Co. has awarded the contract for addition to refrigeration plant on Eaker and Ludlow Sts. to J. Boren & Sons, Columbia St. About $85,000. Noted Feb. 7.

Pa., Phila.—J. Stern & Sons, 428 North 3rd St., have awarded the contract for a 1 story, 22 x 62 ft. boiler house and garage on Cedar and Tioga Sts. to H. Seidman, 5009 B St. About $20,000.

Pa., Venice—The Gilmore Coal Co., Oliver Bldg., Pittsburgh, has awarded the contract for a 1 story, 32 x 93 ft. power plant to Pihl & Miller, Wabash Bldg., Pittsburgh. About $50,000.

Wis., Milwaukee—The Phoenix Knitting Co., 208 Bway., has awarded the contract for an 8 story, 120 x 180 ft. dye house and finishing plant on Milwaukee and Buffalo Sts., to W. W. Oeflein, 86 Michigan Ave. About $500,000. Noted Jan. 31.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

AVERAGE drop of $2 per net ton on magnesite brick and a similar reduction per 1,000 in clay brick. Cold finished shafting and screw stock (rounds) quoted in New York warehouses at $3.35 as against $3.45; flats, squares and hexagons at $3.85 as compared with $3.95 per 100 lb. one month ago. Reductions of 15c. per 100 lb. on structural and boiler rivets at Pittsburgh mills. New York warehouses quote increased discounts on pipe and boiler covering and rubber belting. Babbitt metal also advanced 1c. on best grade and ½c. per lb. on commercial. Linseed oil quoted in New York at 87c. as against 79c.; in Cleveland at 99c., advanced from 80c., and in Chicago at 97c. as compared with 80c. per gal. (5 bbl. lots.) one month ago. Substantial reduction in electrical supplies.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2½-in.	56c. per ft.
Common, 2½-in.	80 per ft. list less 50–5%

Air	First Grade	Second Grade
¾-in. per ft.	$0.31	$0 22½

Steam—Discounts from List

First grade....40–10% Second grade...50–5% Third grade....50–10–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10–5% Best grade..... .... 60–5%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz rolls):

Light Grade	Medium Grade	Heavy Grade
50%	40–5%	35%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 39c. Semi-tanned: cut, 50%; sides, 43c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0 90
Asbestos for high-pressure steam, ½ in.	1.80
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.59
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and Astuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.70

PIPE AND BOILER COVERING—Discounts are as follows:

85% magnesia high pressure		50@55% off
For low-pressure heating and return lines	4-ply	65% off
	3-ply	67½% off
	2-ply	70% off

PORTLAND CEMENT—New York, $2.30 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.63 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	7.50@10.00	12.00	13.00
Colored mixed	5.50@ 9.00	9.00	11.00

WIPING CLOTHS—Jobbers' price per 1,000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$50.00	$55.00
Chicago	55.00	65.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.87	$0.99	$0.97

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	12.25	13.75	15.50	17.00	12.25	15.50
25- and 50-lb. keg	12.50	14.00	15.75	17.25	12.50	15.75
12½-lb. keg	12.75	14.25	16.00	17.50	12.75	16.00
5-lb. cans	15.25	16.75	18.50	20.00	15.25	18.50
1-lb. cans	17.25	18.75	20.50	22.00	17.25	20.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅜ and smaller	60–5%	60–10–10%	65–5%
Tinned	60–5%	60–10–10%	4½c. per lb. net

Structural rivets, ½ to 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York.....$3.50 Chicago.....$3.43 Pittsburgh.....$2.10

Boiler rivets, same sizes:

New York.....$3.60 Chicago.....$3.53 Pittsburgh.....$2.20

REFRACTORIES—Prices in carlots:

Chrome brick, eastern shipping points	net ton	$35@40
Chrome cement, 40@45% Cr_2O_3	net ton	21@23
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	23.50@25.50
Magnesite brick: 9-in. straight	net ton	51@55
Magnesite brick: 9-in. arches, wedges and keys	net ton	56@62
Magnesite brick: Soaps and splits	per ton	72@79
Silica brick: Chicago district	per 1,000	40@42
Silica brick: Birmingham, Ala.	per 1,000	42@45
Silica brick: Mt. Union, Pa.	per 1,000	35@38
Chrome ore crude, 45@50%	net ton	16@18
Magnesite dead burn (Imported)	net ton	26@28
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per 1000	33@38
Clay brick, 1st quality, 9 in. shapes, Ohio,	per 1000	33@38
Clay brick, 1st quality, 9 in. shapes, Kentucky	per 1000	33@38
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana.	per 1,000	28@33
Clay brick, 2nd quality, 9 in. shapes, Ohio	per 1,000	28@33
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per 1,000	28@33

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	32.00	41.00	36.00
Commercial	16.50	13.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$3.35	$3.40	$3.25
Flats, square and hexagons, per 100 lb. base	3.85	3.90	3.75

BOILER SPECIALTIES—F. o. b. **New York** or **Jersey City**, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	60%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	50%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	71	58½	⅛ to 1½	44½	29½

LAP WELD

2	64	51½	2	39½	25½
2½ to 6	68	55½	2½ to 4	42½	29½
7 to 8	65	51½	4½ to 6	42½	29½
9 and 12	64	50½	7 to 12	40½	27½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	69	57½	1 to 1½	44½	30½
2 to 3	70	58½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	62	50½	2	40½	27½
2½ to 4	66	54½	2½ to 4	43½	31½
4½ to 6	65	53½	4½ to 6	42½	30½
7 to 8	61	47½	7 to 8	35½	23½
9 to 12	55	41½	9 to 12	30½	18½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.22
1¼	.....	.....	.21
1½	.....	.....	.1755
1¾	$0.2134	$0.2404	.1936
2	.1638	.2069	.1701
2¼	.1872	.2364	.1944
2½	.1950	.2768	.2280
2¾	.2216	.....	.2584
3	.2470	.3505	.2698
3¼	.2610	.4039	.2925
3½	.2784	.4308	.3120
4	.3538	.5475	.3965

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1½ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 42.00 (net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	30%	20%
Coils to 1,000 ft.	40%	30%
1,000 ft. and over	45%	38%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
½	$45.97	$50.25	$ 9.54	$10.40	$4.09	$4.51
¾	58.28	64.28	12.59	13.81	5.87	6.43
1	83.87	92.18	17.61	19.49	7.53	8.67
1¼	114.00	125.00	24.75	27.15	10.68	11.76
1½	136.20	149.50	32.78	35.90	13.19	14.56
2	172.84	191.30	60.44	66.88	17.58	19.27
2½	288.00	316.15	98.83	108.80	25.10	27.60
3	377.00	414.00	265.22	291.50	37.90	41.60
3½	478.00	566.15	570.06	627.40	51.05	56.20
4	586.00	644.20	670.00	737.50	62.74	68.94

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	⅜ and ½ in. Less 71%
½	250	.06	
⅝	250	.09	
¾	200	.12	Balance 1000 ft. and over 65%
⅞	200	.15	
1	150	.18	Coils.....60%
1¼	100	.25	Less coils, 55%
1½	100	.33	
2	Odd lengths	.40	
	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.08	D. P. D. B.	$0.26
D. P. M. L.	.13	T. P. S. B.	.25
T. P. M. L.	.19	T. P. D. B.	.38
D. P. S. B.	.15		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.38	$1.20	$1.25
T. P. M. L.	.53	1.40	1.80
D. P. S. B.	.47	1.20	.....
T. P. S. B.	.88	2.00	.....
D. P. D. B.	.85	2.35	.....
T. P. D. B.	1.50	4.00	.....
T. P. to D. P. D. B.	1.00	2.75	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$11.50
No. 16 cotton twisted	14.86
No. 18 cotton parallel	15.46
No. 16 cotton parallel	18.70
No. 18 cotton reinforced heavy	21.37
No. 16 cotton reinforced heavy	25.49
No. 18 cotton reinforced light	17.00
No. 16 cotton reinforced light	22.00
No. 18 cotton Canvasite cord	15.40
No. 16 cotton Canvasite cord	18.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	2.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	3.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	5.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 60-5%; standard package, 65-5%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$2.20
0-30 ampere, less than standard package	2.50

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.70	$0.75	50
15	.40	.45	100	100	1.00	1.10	24
25	.40	.45	100	150	1.40	1.50	24
40	.40	.45	100	200	1.90	2.00	24
50	.40	.45	100	300	2.80	2.95	24
60	.45	.50	100				12
				500	4.15	4.40	12
				750	5.75	6.05	8
				1,000	6.70	7.05	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	.26
Swivel attachment plug	.12
Current taps	.36

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.25	$ 8.00	$ 9.55	$15.20
12	8.30	10.10	11.95	19.85
10	10.90	13.00	15.20	25.80
8	14.65	17.05	20.05	34.50
6	.....	.....	30.30	.....
4	.....	.....	40.90	.....
2	.....	.....	61.90	.....
1	.....	.....	82.70	.....
0	.....	.....	102.65	.....
00	.....	.....	121.80	.....
000	.....	.....	146.35	.....
0000	.....	.....	175.15	.....

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap Key Each	¼ In. or Pendant Cap Keyless Each	¼ In. or Pendant Cap Pull Each	⅜ In. Cap Key Each	⅜ In. Cap Keyless Each	⅜ In. Cap Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	15%
1-5th to standard package	30%
Standard package	45%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	34c. lb.
No. 18 B. & S. regular 1-lb. coils	35c lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	21c. lb
Soldering paste, 2 oz. cans	$1.00 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.83	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	5%
$10 to $25 list value	20%
$25 to $50 list value	25%
$50 to $200 list value	35%
$200 list value or over	40%